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THESIS

LEVEL OF PRESENCE OR ENGAGEMENT IN ONE EXPERIENCE AS A FUNCTION OF DISENGAGEMENT FROM A CONCURRENT EXPERIENCE

by

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It is uncertain what effect presence has on virtual environments (VEs) but it is believed to enhance both learning and enjoyment. To date, there exists only subjective methods of measuring the level of presence in VEs. In order to effectively utilize VE technology, it is necessary to gain a greater understanding of presence and the factors that affect it. Therefore, we need to develop a quantifiable method of measuring presence. This metric would provide a framework for design requirements for predictable, repeatable performance in VEs.

To investigate a proposed new metric, 70 individuals participated in an experiment based on the dual task paradigm of attention theory. The purpose of the experiment was to determine the level of presence or engagement in one experience as a function of disengagement from a concurrent experience. Participants received two simultaneous experiences, one virtual, the other real, and were given quizzes on each to determine their focus of attention at various stages.

Results indicate 1) HMDs occlude all but one of concurring experiences preventing the dividing of attentional resources. 2) Including sound increases the level of engagement in an experience and allows for dividing of attentional resources between concurrent experiences. 3) Responses to previously established presence questionnaires correlate strongly with this new measurement of engagement indicating that this method does have validity. 4) Primed participants exhibit a decrease in levels of engagement in both experiences due to the focus of attention being divided.

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LEVEL OF PRESENCE OR ENGAGEMENT IN ONE EXPERIENCE AS A FUNCTION OF DISENGAGEMENT FROM A CONCURRENT EXPERIENCE

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ABSTRACT

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I. INTRODUCTION

The United States Military faces a real dilemma today. How can we continue to maintain readiness during downsizing, changing technologies, increased resource constraints, and the continuing evolution of the United States Military role in a post cold war era? Technology is one part of addressing this problem.

Over the past two decades, the United States Military has been at the forefront of virtual environment (VE) research. It has invested billions of dollars in the development of computerized training devices to assist in training soldiers in war fighting and survival skills. VEs have been used for general training and preparation for real campaigns in ways such as simulating battle conditions and environments and training personnel in the use of new equipment, such as portable air defense missiles [ZYDA 97].

Training in VEs has been primarily for soldiers who operate and fight from within vehicles, e.g., tanks and helicopters. The idea that these virtual battlefields will also allow for safer, less expensive and, in many ways, more flexible training for foot soldiers is gaining attention [LAMP 94]. VE technology still has cost and performance limitations that preclude the widespread application of the technologies necessary for training dismounted soldiers [LEVI 93]. Current interest and research in this area can support and guide future development of VE training systems as technology matures. VEs will continue to play an important role in the future from a military as well as civilian standpoint.

A. PRESENCE AS A DEFINING CHARACTERISTIC OF VIRTUAL ENVIRONMENTS

VEs are a set of computer technologies which, when combined, provide an interface to a computer-generated virtual world that can be considered an "alternate experience" [HELD 92]. This computer-generated world may be a model of a real-world object such as a military base or tourist attraction. It might be an abstract world that does not exist in a real sense but is understood by humans. Examples include a chemical molecule, a representation of a set of data, or a completely imaginary, fictional world.

The key feature is that users may believe that they are actually in an alternate experience that contends with the real experience. This psychological sense of "being there" is referred to as the sense of presence. This can be achieved when multiple sensory modalities of the user are stimulated by display systems that create an illusion of an alternate environment into which the user enters. The research referenced in this thesis indicates that sight and sound are the primary modalities having the most profound effect when stimulated. Sound and touch combined also give convincing evidence of being in the VE. Ideally, there are negligible stimuli from the real environment (RE) and as many modalities as possible are stimulated to create the illusion of the desired VE. Thus, what the user sees and hears when stationary, moving, reaching out, touching objects, detecting odors, and so on, should result in an effect that is convincing and consistent. The use of a virtual body with accurate matching and mapping can also provide feedback that would be expected in a corresponding RE.

Research in this area has been increasing recently. The issue of "presence" or "immersion" is often discussed in the literature. However, there is very little information or agreement as to what it means in terms of performance or satisfaction. Presence is still

poorly defined but it is generally believed that the greater the number of human senses for which a VE provides stimulation, the greater the capability of the VE to produce a sense of presence. Since it is computationally impossible to make an actual representation of the real world within current computing constraints, we need to determine what stimuli are necessary to provide the highest possible level of immersion and its related presence.

B. RELATING PRESENCE TO PERFORMANCE

The effect of presence on performance in VEs is not yet understood. In fact, it has been stated that this area of research in VEs is still in its infancy [SLAT 96]. It is generally believed that greater levels of presence will result in better performance. This comes from the idea that training in a VE provides convincing "practice" for reactions to situations that may occur in real life. The more presence an individual is able to attain, the more likely it is that they subsequently will respond similarly to situations they may encounter in the RE and that they will transfer that knowledge to RE situations. Training VEs need to closely match real world training environments in terms of stimuli fidelity and interface fidelity. A great sense of presence may actually be a detriment in a training environment that uses interface equipment that is completely different than the equipment used in real situations or lacks the same details. The trainee may become so accustomed to using the VE interface that they become distracted and respond improperly when placed back in the RE. This "reverse training" could prove a serious problem in many occupations.

Creating safe, cost efficient, accessible VEs for training soldiers requires a specific, detailed understanding of how presence is achieved, how it works, and what

effects it has on task performance and training transfer. Understanding presence and having a quantifiable measure for presence will provide parameters for engineers when designing all types of VEs. If we never gain an understanding of this powerful cognitive force it will greatly limit our ability to use this area of science to create efficient, useful tools for training, entertainment, and education. With advances in PC-based systems, we may even be able to transfer these models to desktop systems for use by soldiers at the unit level rather than using a limited number of large scale computing centers. This will help make such systems more available and reduce the overall need of expensive single purpose systems for the Department of Defense.

C. QUANTIFYING PRESENCE

Currently, the primary method of measuring presence is a subjective measure and is provided by participants' self-assessments via questionnaires. One of the problems with this type of measurement is that there are far too many variables; differences in individual's primary representation scheme, moods, motivation, ability to communicate their experiences, just to name a few. Even the same individuals may perceive entirely different experiences on any given day. This prevents creating a solid, quantifiable, repeatable measure.

Ideally, we would have a metric scale on which we could place each type of technology or combination of technologies to achieve any level of presence necessary for the training, educational, or entertainment environment applicable to our needs. The potential benefits of such a metric make it worth working toward such a goal.

Computers have become a way of life for this generation and will continue to evolve, becoming more user-friendly and interactive, and remain a way of life for future

generations. The increased use of computers by the general population and escalating interest in the applications of VEs has produced numerous theories regarding presence and its effects. VE technologies, which have become available in the past decade, offer dramatic new approaches to the core goals of training, particularly as they increase the user's immersion and sense of presence. The continuing evolution of VE science indicates a real need for quantifiable measures for presence.

D. RESEARCH OBJECTIVES

The primary focus of this thesis is to develop a new measure of presence based on attention theory and to use this measure to evaluate the effects of visual and aural displays on presence. This thesis limits its focus research to one real time VE. The levels of immersion provided by different visual and aural display parameters are identified. These visual and aural parameters are used to develop both subjective and objective measures of presence in order to quantify the level of presence experienced within the VE. To accomplish this goal an experiment was performed which will be described later in this thesis.

The following questions are examined to help understand presence:

- Are there objective measures that can quantify presence?
- How much of the synthetic experience occludes a concurrent real experience and is this measurable?
- Do media that provide both aural and visual stimuli produce a greater sense of presence than audio-only (or video-only) media?
- Which apparatus supports a greater sense of presence? Head-mounted visual display, 3-screen display, flat-screen display, head-mounted visual display with sound, 3-screen display with sound or flat-screen display with sound?

E. THESIS ORGANIZATION

This thesis is organized into the following chapters:

- Chapter I: Introduction. This chapter gives a general outline of the organization of the thesis. It addresses the significance of introducing and evaluating a new paradigm for the measurement of presence. In addition, this chapter also covers the major objectives and the motivation behind the thesis.

- Chapter II: Background and Previous Work. Current and past works that relate to the research conducted in this thesis are discussed. This chapter also defines the conceptual framework and theoretical basis of presence, immersion, and attention theory as described by current literature.

- Chapter III: Approach. This chapter proposes new methods for measuring presence. In addition, this chapter discusses how this new measurement of presence was developed and the variables which are believed to influence the degree of presence users experience when interfacing with virtual environments.

- Chapter IV: Method. This chapter describes the experiment and six different treatments used to investigate the levels of immersion provided by the different visual and auditory display parameters. In addition, these parameters are used to develop subjective measures of presence in order to relate the amount of presence experienced within a virtual environment.

- Chapter V: Model Development. Describes the development of the virtual environment and the external stimuli environment models.

- Chapter VI: Analysis. Analysis of the efficiency of the prototype in terms of stated hypotheses is discussed. This chapter also covers the user interface and hardware requirements.

- Chapter VII: Conclusions and Recommendations. This chapter provides an overview of the results obtained in this experiment and their significance in terms of directing future studies evaluating this new objective measure of presence in virtual environments.

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    C. In-briefing script
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    E. Questionnaires and tests
    F. Virtual research V8 HMD specifications

II. BACKGROUND

A. INTRODUCTION

Theories for measuring and attempts to define immersion and presence have become a point of interest for a rapidly growing number of researchers. The reasons for this range from increased enjoyment of the participants in recreational or entertainment equipment to safer, more economical, and more efficient means of training medical personnel, firemen and other dangerous occupations as well as for psychotherapy. ***To date, there is no definitive, quantifiable, metric for measurement of presence.***

Slater, et al, suggest there is a distinction between ***immersion*** (the technology used to create a VE) and ***presence*** (the cognitive response or sense of "being there" a participant experiences in an VE) [SLAT 97]. This framework will be used in this thesis.

What purpose does defining immersion and presence serve? An enhanced sense of presence is the general desire for VE creators, the entertainment industry, and the many fields that work with communication technologies. Increasing the level of enjoyment for participants in recreational industries or creating a true sense of presence for people using video conferencing or other telecommunications may increase the efficiency of information sharing. The realness of an experience is one of several vital elements in telepsychiatry used in psychotherapy to treat patients suffering from severe phobias and other traumatic life experiences[ROTH 96][HODG 95]. All tools and applications used by people continually strive to increase their efficiency at whatever their purpose may be, whether that purpose be strictly for entertainment, learning, or performance. An increased understanding of presence, its attributes, and vital characteristics that encourage or discourage the sense of presence in participants, will save valuable time, money, and

effort in improving the technologies of present and future communications media, and in particular, VEs.

Research in this area, thus far, has been relatively unsystematic and inconclusive regarding presence. The fact that persons interested in researching presence come from diverse fields including, but not limited to, communication, psychology, cognitive science, computer science, engineering, philosophy, and the arts may be a factor in the obstruction of common research methods and goals and conclusive answers to the many questions that need to be addressed regarding presence.

In order to better understand the concept of immersion and presence and how it can be used in a VE application, a brief background is presented in the following areas: virtual environments, immersion, presence and attention theory.

B. VIRTUAL ENVIRONMENTS

The term "Virtual Reality", often shortened to VR, was first coined by Jaron Lanier, founder of VPL Research Inc. The term "Virtual Environment", or VE, is an often used alternative to describe VR, as it implies more than just the technology; particularly content, applications, and even social issues. For the remainder of this thesis the term VE will be used. Many people claim that the originator of the concept of VEs is science fiction writer William Gibson in his book, Neuromancer [GIBS 94]. In fact, Gibson was not responsible for the original idea of VEs. The title of "originator" if such a title must be given, is more appropriately awarded to Ivan Sutherland, who started research in this field in 1965. A computer graphics pioneer, Sutherland described an "ultimate display" that included full-color, stereoscopic, high-resolution imagery, filling

the user's entire field of view [SUTH 65]. He also expresses an interesting and useful view of the phenomenon of presence:

> ***A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland... There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality... The ultimate display would, of course, be a room with which the computer can control the existence of matter.***
>
> ***[SUTH 65]***

As the user moved, the surrounding image would simultaneously adjust to provide the illusion of existence inside the artificially created world. In addition to completely realistic-seeming imagery, the ultimate display would include high fidelity, directional sound, which would allow the user to accurately "hear" the created world, and also provide a feeling of motion to the user. In other words, a synthetic experience that replaces the RE.

VE technology is the result of a convergence over many years of real-time graphics displays, cybernetics, database design, real-time and distributed systems, robotics, multimedia, three dimensional audio, tracking equipment, computer aided design (CAD), and cinematography technology. In short, VEs are computer system combinations designed to transport the user to a different synthetic environment. The environments can range from models of real world objects and places to abstract worlds that do not exist in a real sense but are understood by humans, such as a DNA or chemical molecule or a representation of a set of data; or it might be a completely imaginary, fictional world.

VE systems have seen their widest application in flight simulators. A pilot trainee sits in a simulated cockpit mounted on a hydraulic platform. Views outside of the plane are projected onto a large screen display. As the plane is flown, the images simultaneously adjust. This same technology has found its way into our living rooms. Home video game equipment provides high-quality, three-dimensional rendering. Outside the entertainment industry, VEs have been successfully used in fluid dynamics visualization, medical training and practice, architecture, and elementary education, among others.

A variety of flavors of VEs have been identified. Immersive VEs completely replace the RE with an artificial world; that is, the user is completely immersed in the artificial world [SLAT 93]. Fish-tank VEs create a three-dimensional artificial world inside the square box (the fish tank) of a computer's screen [WARE 93]. Augmented Reality superimposes digital information onto the RE, for example, projecting a CAT scan image onto a patient during an operation [LORE 93].

One key feature of VEs is that if a user moves his head, arms, or legs, the shift of visual cues must be those he would expect in a RE. In other words, there must be "natural" navigation and interaction. Another key feature is that the user should believe that he is actually in this different world. In other words, they experience a sense of presence. This can be achieved when the user's sense of sight, touch, smell, sound, and taste are stimulated by some means in the VE and they simultaneously become unaware or detached, to some degree, from the RE. However, the senses of sight, sound, and touch predominate due to technology constraints. Ideally, stimuli sensed from the RE

should be kept to a minimum. Thus, when the person moves, reaches out, sniffs the air, and so on, the effects should be convincing and consistent [PIME 95].

C. IMMERSION

Pimentel and Teixeira suggest that the experience of being immersed in a computer-generated world involves the same mental shift of suspending disbelief for a period of time as when one is wrapped in a good novel or becomes absorbed in playing a game or watching TV.

Level of presence is enhanced when the immersive technology is able to provide a deeply convincing illusion of reality for the participant in the experience. Steuer describes four factors that contribute to enhanced immersion. He states that the computer displays need to be:

- Inclusive (I) - Indicates the extent to which the surrounding "real" world is shut out;
- Extensive (E) - Indicates the range of sensory modalities accommodated;
- Surrounding (S) - Indicates the extent to which this VE is panoramic rather than limited to a narrow field; and
- Vivid (V) - Indicates the resolution, fidelity, and variety of energy simulated within a particular modality) illusion [STEU 95].

While it is true that these factors can each be quantified, their connection to presence is unknown. However, these definitions are useful in describing immersive technologies in a consistent fashion.

1. Inclusive

Inclusiveness would include any combination of technological devices that would enable the participant to willingly suspend disbelief for a period of time. To the greatest extent possible, the participant should remain unaware of the devices being used to simulate the VE such as the edges of displays, speakers, microphones, measurement devices, keyboards, controls, or lights. Mathew Lombard describes this as an "illusion of non-mediation" [LOMB 97]. An illusion of non-mediation occurs only when the participant does not perceive or acknowledge the existence of the technology used to simulate the experience and responds in the same way they would if the technology were not there at all. Lombard suggests that the illusion of non-mediation can occur in two distinct ways:

- The medium can appear to be invisible or transparent and function as would a large open window, with the medium user and the medium content (virtual objects and/or entities) sharing the same physical environment.
- The medium can appear to be transformed into something other than a medium, e.g., into a social entity.

Held and Durlach suggest that the signals that would impair this illusion could include three categories.

- Those caused directly from the display system, such as aliasing and the rate of update.
- The input systems, such as interference induced by metallic objects in the electromagnetic sensors.
- The physical properties of the devices themselves, such as the bulkiness and weight of the HMD unit or the connecting cables [HELD 92].

The attempt to induce such an illusion is currently a challenging, if not impossible, task to achieve. In time, technology will achieve a much greater degree of seamlessness and the effect it will have on presence should be better understood.

2. Extensive

Extensiveness could be limited depending on the environment in which the experience takes place, the modality in which the participant shows the most dominant sense of perception, and the quality of the display devices being used. Obviously, it would be more crucial to use a HMD (head mounted display) to increase visual and aural fidelity if the experience is taking place in a crowded, loud arcade as opposed to taking place in a quiet, dark laboratory designed with sound proofing. A lower degree of immersion is achieved when using only a flat screen and speakers and equipment that allows for little or no interaction. The lesser the range of modalities stimulated, the lesser the degree of immersion. Conversely, the greater the range of modalities stimulated, the greater the degree of immersion. However, this is probably only true to a certain point because the sensory modalities can only handle so much information before they become overloaded.

Vision has been overwhelmingly accepted by VE researchers as the major, or dominant, sensory modality. Although considered to be of lesser importance, it is clear that sound plays a significant role in presence [GILK 95]. Discoveries reported by Robert Gilkey regarding previous research by Ramsdell [RAMS 78] are of particular interest. Gilkey found striking similarities between language used to describe the world by the suddenly deafened subjects in Ramsdell's study and that used to describe VE experiences. The similarities were the repeated description of the world of the deaf observer as "dead"

and lacking movement, and the frequent use of terms like "connectedness", "part of", and "coupling" to describe the psychological effect that hearing has on the relationship between the observer and the environment.

Ramsdell provides an interesting view of the auditory modality in terms of three levels: the ***social level***, the ***warning level***, and the ***primitive level.***

- The social level is that of everyday communications (e.g., talking and singing) which involves extracting and interpreting symbolic auditory symbols.
- The warning level is that which occurs suddenly and alerts us to something occurring in our surroundings such as a gunshot, a siren, the telephone ringing or a baby crying. Both of these first two levels require some awareness of the existence of the sound source.
- The primitive level does not require such conscious awareness. It is described as the everyday sounds surrounding us that are neither symbolic in nature nor a source of warning. This is also known as ambient noise. This includes sounds such as the wind blowing, a clock ticking, our own breathing and other sounds resulting from everyday interaction with the environment. This level of hearing is that which couples us with reality.

> ***These incidental noises maintain our feeling of being part of a living world and contribute to our own sense of being alive.***
>
> ***[RAMS 78]***

This may indicate the importance of sound on presence. The enhancement of aural stimulation with this primitive level of "background" noise may enable a much greater degree of immersion and therefore a much greater sense of presence.

The remaining sensory modalities can be stimulated but are often not primary factors in controlling such media. The uncertainty of their effectiveness and the tremendous expense of such devices limits their use. Past attempts to stimulate the olfactory sense include releasing aromas during an arcade attraction called Sensorama

[HELL 92] and scratch and sniff cards given to viewers watching the movie Polyester in a theater [WATE 81] to share in the experiences of smell with the film's heroine. Physical movement of participants' bodies has been, and still is, mediated in movies like Earthquake [LANG 74], Gunnm [IKEG 93], Midway [MIRI 76], and Rollercoaster [BUMS 77] [LOMB 97] with the use of seats that vibrate and hydraulic motion platforms for sophisticated flight simulators and simulation rides such as those at Disneyland and other theme parks. Whether or not these sensory modalities help provide a sense of presence is not clear and may vary depending on each situation. A good example is an experiment described by USAF General Larry Welsh (ret) involving fighter pilots and cargo plane pilots. Each group used simulators that included platform movement. The movement of the platform was gradually reduced and finally stopped all together. The experienced fighter pilots reported not noticing the absence of platform movement. However, the cargo plane pilots reported noticing the absence of movement. The fact that the cargo plane pilots normally had to perform tasks such as writing on clipboards and were accustomed to having to cope with the constant motion made them more aware when the motion was absent than it did the fighter pilots who, normally, perform no such tasks [WELS 97].

The two remaining modalities can only be stimulated during an interactive experience. Instrumented gloves can produce stimuli to simulate tactile sensations such as touching ("feeling" textures). Force feedback can be produced with special devices such as joysticks and steering wheels.

The use of Virtual Bodies (VBs) has received many positive responses from subjects participating in VEs. It appears that the VB helps maintain the egocentric

perceptual position and enhances the "realness" of the experience. Meredith Bricken notes that watching a dynamic representation of one's hand within a VE is "convincing evidence that you are there" [BRIC 91]. Research has indicated the importance of the VB's appearance being similar to that of the participant and matching movements as closely as possible also known as mapping. VBs should allow the user to interact with the environment, particularly with any virtual beings.

3. Surrounding

"Surroundness" includes not only the panoramic field of view but also the depth of field or three-dimensional visual and aural perception. Not surprisingly, research has shown that head tracking is a vital component in the greater level of enjoyment for participants. However, if not done correctly, it can have the reverse effect. Hendrix cautions the integration of head tracking in display units [HEND 96]. Task performance may be affected negatively if there is a sufficiently large temporal lag in the device used to track head motion [SMIT 62] and presumably, the level of presence would also be negatively affected. Head tracking may also cause some participants to experience motion sickness. Head tracking, however, if used properly can greatly enhance the environment. Hendrix reported the following reactions to the addition of head tracking; participants standing on the chair to see the top of objects, standing and stooping, turning sideways or backward and looking back over their shoulder at the display screen, tilting their head sideways, and leaning forward and backward in their chair. Hendrix suggests that the addition of a task to be performed by the participant within the VE may further "pull" them into the environment and exploit the benefits of the parameters used to design the display.

Our ability to interact with our environment is directly related to accurate visual and aural spatial perception. Although a particular device or chosen field of view (FOV) may improve the participant's level of "visual-realism", it may not allow realism in their ability to interact with the environment. Therefore, it may be better in terms of presence to provide a less photo-realistic [HEND 96] environment and to create a more naturally interactive or spatially-real environment. Correct visual spatial illusions have been created by artists in paintings and drawings for centuries and are now an increasingly important task of the designers of VEs. A remarkable example from history of an artist creating this illusion is described by Lombard.

> ***Near the end of the 17th Century, Andrea Pozzo painted The Glorification of St. Ignatius on the ceiling of the Church of Sant' Ignazio in Rome. Today spectators still look up to see a three-dimensional panorama of arches supported by columns, windows, and sky, with human figures arranged in various positions throughout, some of them seemingly suspended in midair... It looks real, so real that it is virtually impossible to tell where the architecture of the church ends and the painting begins.***
>
> ***[ROCK 84]***

The tricks used by artists to capture this illusion include making objects in the foreground block items in the background (interposition) and making the more distant items smaller and less detailed. These techniques are still used by visual artists and VE designers in one form or another.

As stated earlier, the importance of aural stimulation is often overlooked. Just as we see in "three dimensions", we also hear in "three dimensions". Dimensional hearing is produced in stereo (two channel), quadraphonic (four channel), and especially in surround

sound systems (in which the amplitude, phase, and frequency of sounds arriving at each ear are adjusted to create the illusion of dimensional space).

4. Vividness

Vividness, richness, or quality of the computer-generated environment is affected by the combinations of technology and devices used to stimulate various modalities in the VE. The major types of devices used for three-dimensional visual stimulation share common characteristics; spatial resolution, depth resolution, field of view, viewing zone, bandwidth, etc. The technology to be used needs to be chosen according to the task to be accomplished. It appears that if the task is more performance-oriented or educational in purpose, higher resolution may not be necessary. However, if the task is purely for pleasure or for the end goal of a deep sense of presence through immersion, higher-quality resolution would be desirable [STEU 95]. The technology used should provide as much fidelity as possible and produce information consistently across all displays and modalities. Ideally, all modalities would be stimulated in the VE; however, this is usually not possible nor practical.

D. PRESENCE

"What is now needed is a systematic research effort designed to gain an understanding of the sensorimotor and cognitive factors that determine the sense of presence." [HELD 92]

1. Defining Presence

Defining presence remains an elusive goal. However, Lombard and Ditton have presented a defining structure of six Presence Conceptualizations that follows.

a. *Presence as Social Richness*

Presence as social richness relates to two important concepts normally applied to "real" interpersonal communication: intimacy and immediacy. The level of intimacy that the participant becomes comfortable with is achieved and indicated by physical proximity, eye-contact, intimacy of conversation topic, amount of smiling, and other behaviors to establish an equilibrium between conflicting approach and avoidance forces. It is also suggested that behaviors indicating level of intimacy include the participant's posture and arm position, trunk and body orientation, gestures, facial expressions, body relaxation, touching, laughter, speech duration, voice quality, laughter, and olfactory cues [CAPP 81][MEHR 69][PATT 73]. Immediacy has to do with language familiarity. The capacity for immediate interaction is, of course, influenced by understanding and being comfortable with the language used by the display system.

b. *Presence as Realism*

Presence as realism is concerned with how accurate the objects, events, and people are reproduced in the VE. This conceptualization depicts two types of realism. Realism in the social sense indicates that which is "true to life" or events that could actually, logically take place in the real world. Perceptual realism includes events that could not logically take place in the real world but only in an "unreal" environment such as a science fiction movie or an abstract VE.

c. *Presence as Transportation*

Presence as transportation includes three distinct types of transportation.

- "You are there" - users are transported to a place other than where they actually are.

- "It is here" - the places and objects of the VE are transported to the user.
- "We are together" - two or more users are transported to a virtual place together.

Included in the "you are there" aspect of transportation are both virtual presence and telepresence. Virtual presence is the "feeling" of being in the environment generated by technology. Telepresence is the "feeling" of being at a remote location -- telepresence can be accomplished in a telephone conversation or a virtual tour of a museum.

An extreme example of "It is here", as recorded by Schoen, is the theatre-goers at the beginning of the film era that are said to have panicked and run for the exits when a black and white film of an oncoming locomotive was shown. A typical question asked after this type of experience was, "How much did you feel like it was happening to you?"[SCHO 76].

Video conferencing and shared virtual experiences are examples of "we are together". Present "chat rooms" are believed to be precursors to future shared VEs that will be a gathering place for people from around the block or around the world.

d. *Presence as Immersion*

Presence as immersion emphasizes the idea of perceptual and psychological immersion. The concept is that of being "immersed" in the VE -- of being "engulfed" by the environment. The technology used helps disconnect the user from the outside world. Perceptual immersion can be objectively measured, according to Kim and Biocca, by counting the number of senses that are provided with input and the degree to which inputs from the actual physical environment are "shut out" [KIM 96]. The

psychological component of presence as immersion involves the degree of engagement, involvement, or of being engrossed in the experience. This component is typically assessed with user self-assessment. This thesis, in part, will address this issue in a different way,

e. *Presence as Social Actor Within Medium*

Participants in VEs often respond to cues from virtual beings in the environment even though it is seemingly illogical to do so. The fact that the experience is mediated is ignored and the virtual person is perceived and responded to as though it was a social actor. For example, the current rage in America is the cyberpet. The participant (owner) interacts by responding to cues from the cyberpet indicating that it is hungry, needs exercise, medicine or playtime, even discipline by providing whatever it is that it needs. This is on a small scale of presence as social actor but an interesting example nevertheless.

f. *Presence as Medium as Social Actor*

Because computers are more and more frequently being used in roles traditionally filled by humans, users often respond to them as though they were social entities. Modern computers may use natural language and interact in real time making it more natural for users to interact with them in this capacity.

2. Measuring presence

These six presence conceptualizations provide a good start to understanding the types of presence that can occur within a VE. Many experiments have been performed in an attempt to further identify factors that increase the sense of presence. Ideally,

researchers and VE designers would have a quantifiable, repeatable metric to measure presence. However, no definitive, quantifiable metric of presence exists to date. The purpose of this thesis research is the further development of such a metric.

Slater and Usoh distinguish between external and internal factors contributing to presence. External factors are the technology used to create the VE and the devices used for sensory stimulation [SLAT 93][SLAT 94]. It is generally believed, as stated earlier, that a greater degree of immersion (technology) will heighten the sense of presence. Internal factors are much more subjective and more difficult to quantify. These factors include the wide range of responses of different participants to identically produced external stimuli. Internal factors are best measured by the participants themselves in the form of a questionnaire before and/or after a VE experience. Up until now, the questionnaires used prior to a VE experience were directed at identifying their primary mode of representation system (visual, auditory, kinesthetic) and the individual's perceptual position; egocentric or exocentric [BAND 79]. The questionnaires used following the VE seek subjective self-assessment of the individual's experience. Slater, Usoh, and Steed used three indicators to assess the responses given [SLAT 94b].

- Did the participant experience a true sense of "being there"? - An analysis of the overall psychological state of the participant while experiencing the VE.
- To what extent did the participant come to believe that the VE was more "real or present" than the RE in which the experiment took place?
- To what extent did the participant view the "location" of the VE as more of a place visited rather than an image seen?

Lombard expresses an interesting and useful view of the phenomenon of presence:

> ***Presence does not occur in degrees but either does or does not occur at any instant during media use; the subjective feeling that a medium or media-use experience produces a greater or lesser sense of presence is attributable to there being a greater or lesser number of instants during the experience in which the illusion of non-mediation occurs.***
>
> ***[LOMB 97]***

This concept could provide a working theory for an objective, quantifiable method for measuring presence in a VE. Imagine being able to take any VE experience and break it down into slices of time, say five second intervals, creating a task that is simple yet requires focused attention (causing the illusion of non-mediation) within the VE to be performed by the user at each five second interval and measuring a simple 'yes' or 'no' to each task throughout the experience. Theoretically, the user would either attend to the VE to perform the task or they would become distracted and not perform the task. A simple analysis of the number of 'yes' answers could be used as a basis to create a metric for presence. This idea is probably a long way from being usable but it suggests one possibility for an objective, quantifiable metric of presence.

Theoretically, measurements of presence can be objective and/or subjective. Objectively, a participant can be observed and notice taken of the physiological responses to a VE experience. If the participant sits motionless, expressionless, and has very little opportunity for interaction in the environment, the level of presence would be considered at the low end of the scale. If the participant has access to a high level of interaction with the environment (as with a full body experience where all modalities are stimulated and there is a great degree of fidelity provided by the technology used), it would probably be

obvious, outwardly, to the observer that the level of presence would be at the high end of the scale.

An experiment conducted by Slater, et al, further supports the theory that full body movement greatly increases the "behavioral presence" of participants [SLAT 98]. Behavioral presence is the responses of the participant that are clearly observable to the experimenter. Along with the obvious physical responses such as ducking and moving in response to stimuli, there are also physiological observations that can be measured and analyzed such as heart rate, respiration, and biofeedback. However, the fact that these physiological aspects can be measured does not necessarily mean that the information can be correlated back into presence.

3. Relating Presence to Performance

Interactivity has been noted several times above as being vital to a deep sense of presence. The level and quality of interaction between user and technology is a common factor that arises in the literature discussing presence. Interaction involving multiple processing functions provides what appears to be the deepest sense of presence. The ability of the user to change the environment at will using familiar sensorimotor skills to manipulate objects and "feel" textures, to speak in a VE with a familiar and expressive language, to be stimulated in as many modalities as possible and be able to respond to the stimuli in those respective modalities, and to do all of this in "real time" creates the most interactive environment currently possible. However, even if we knew for certain that interactivity raises presence, this says nothing about the reverse. Does presence correlate with performance? Further research in needed on this topic.

E. ATTENTION THEORY

Attention is the ability to direct mental concentration at a chosen target. It is assumed that the overwhelming majority of stimuli actually received is confined to that attended to. Getting the attention of a user in a VE appears to be a very simplistic goal. However, receiving stimuli from two competing sources (e.g., that from the VE and the RE simultaneously) causes dual task contention. One competes with the other for attentional resources.

The four design requirements described by Stuer serve as guidelines for display characteristics to increase and direct the general demand for attentional resources consistently throughout the modalities so that the user is drawn to attend to the VE rather than the RE. Knowing how to minimize or prevent competing task interference between the RE and the VE is an important element of creating a convincing illusion of presence in a VE. It is assumed that if a user is "present" in a VE, attention is focused within the VE. Therefore, if it can be shown that attention is anywhere other than the VE, then the user is <u>not</u> present, to some degree.

There are four recognized forms of limitations of human attention [BENN 96]:

- Limits of selective attention (e.g., concentration on one event/task to the exclusion of another).
- Limits of focused attention (e.g., the inability to shut-out the distraction of other events/tasks).
- Limits of divided attention (e.g., the ability to monitor two or more events/tasks effectively).
- Limits of sustained attention (e.g., the sustained process of selective attention for a prolonged period).

For the purpose of this thesis, the resource hypothesis was used to examine the attentional phenomena in dual tasks. Within the dual task paradigm, attention is an inferred construct used to describe the cost in performance of the two tasks associated with their concurrence [WICK 80]. The resource hypothesis encompasses a broad spectrum of phenomena and varied resource theories [DARK 93]. The resource hypothesis suggests that attentional resources exist in a single pool or a number of pools called structures.

Wickens suggests these structures can share or divide their resources between concurrent tasks and are allocated as dictated by demands and priorities [WICK 80]. If demand exceeds the capacity in one structure, resources from another structure can be transferred but with some reduced efficiency. Structures themselves cannot be divided across tasks. These structures and pools should be viewed as metaphors, used to describe conceptions and should not be taken literally.

Among the attention theories of early selection [BROA 58], late selection [DEUT 63], single capacity [KAHN 73], and multiple resources [NAVO 79][WICK 84], there is a notion of a bottleneck of some sort. Filter (or bottleneck) models postulate the existence of a structure at some processing stage that allows only a limited amount of information to pass onto the next stage. However, the location, albeit abstract, of the bottleneck is controversial.

Capacity models assume that our mental resources are finite and different sensory inputs and task responses require different amounts and types of mental resources. Thus, attention is the process or mechanism that allocates mental resources to different inputs

and tasks. It is believed that the bottleneck occurs somewhere within the allocation of resources to supply the demand required by current tasks.

This bottleneck appears to occur within the limited capacity (resource) channel when applied to the early selection theory and within the storage system when applied to the late selection theory [DARK 93]. See Figures 1 and 2 below, both of which are adapted from Norman [NORM 76].

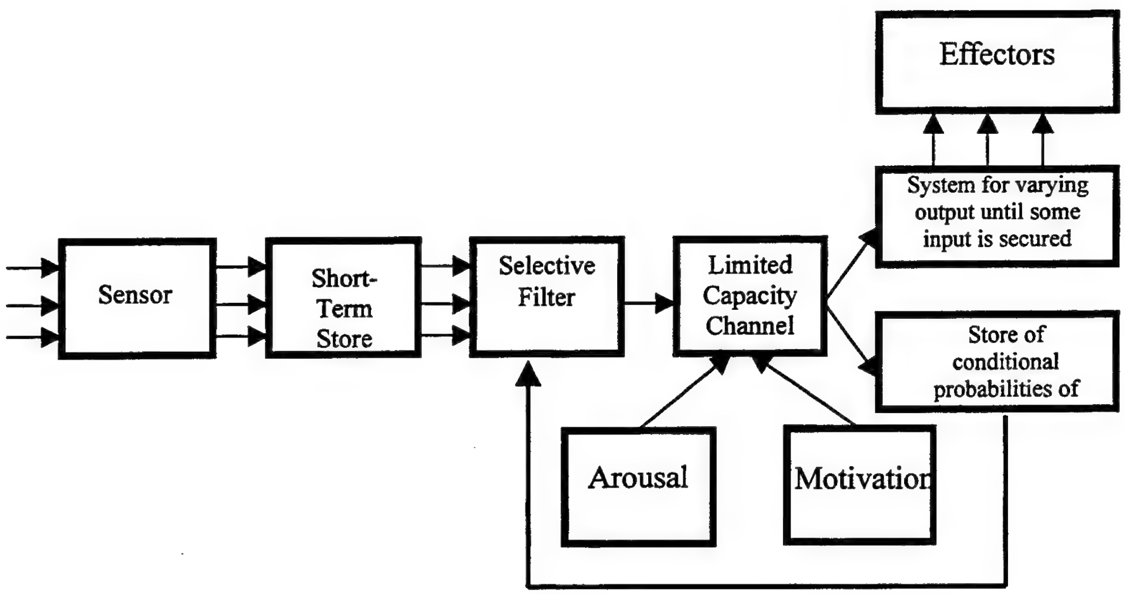

Figure 1: The Early Selection Model

In Figure 1, resource allocation would take place within the limited capacity (resource) channel. The size of the capacity is affected by arousal and motivation.

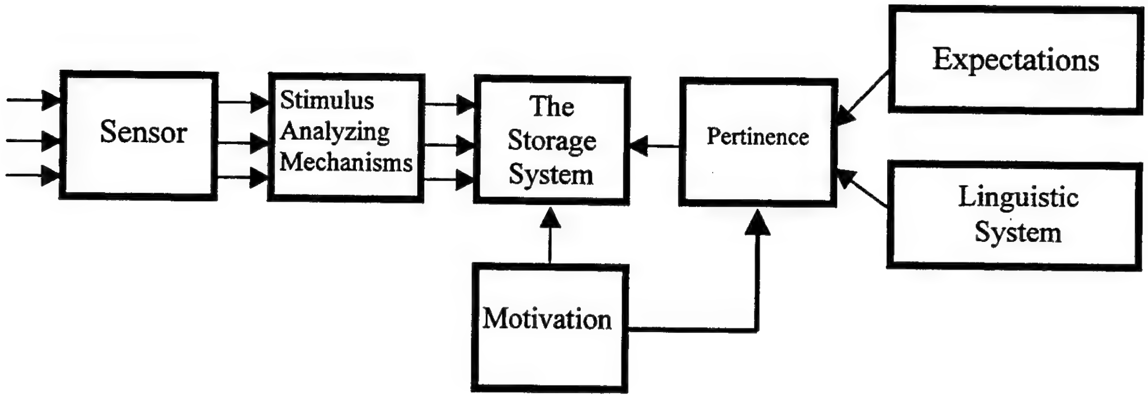

Figure 2: The Late Selection Model

In Figure 2, resource allocation would take place within the storage system after all stimuli have been analyzed.

Evidence was presented by Hirst and Kalmar [HIRS 87] supporting their suggestion that not only do multiple pools of resources exist but that the number of pools is flexible and can be affected through practice and learning. Participants in their experiment found that it was easier to perform one task while doing a second if the tasks were different. It was harder for them to perform two tasks simultaneously if they were the same two tasks. The demand for resources from the same pool caused deterioration of task performance. Conversely, there was less deterioration of task performance when the resource demands were from different pools.

It is believed that visual and aural stimuli demand resources from different pools. Therefore, it is possible to perform tasks with stimuli from these two modalities simultaneously. However, receiving visual stimuli from two different sources concurrently is believed to cause dual task interference that leads the processing system to dedicate more resources to one than to the other. Aural stimulation from two different sources causes the same dual task interference.

There are, however, situations in which concurrent tasks would actually interfere constructively and increase performance. Wickens, et al, [WICK 83] introduced an addition to a previous method of analysis of stimulus and response combinations, the S-R compatibility method [FITT 53]. The model for resource definition Wickens proposed added a central processing component (S-C-R compatibility).

The S-R method suggests that the rate of information transfer is proportional to the amount of S-R compatibility. In other words, if the stimuli and response are not compatible, excessive recoding of information is required which will lengthen the amount of time involved in the process. Earlier work by Wickens [WICK 80] defined codes of processing as a fundamental dimension of resource description. The S-C-R compatibility model is based on the attempt to divide the hemispheres of the brain based on what has been learned about spatial and verbal subdivisions. See Figure 3.

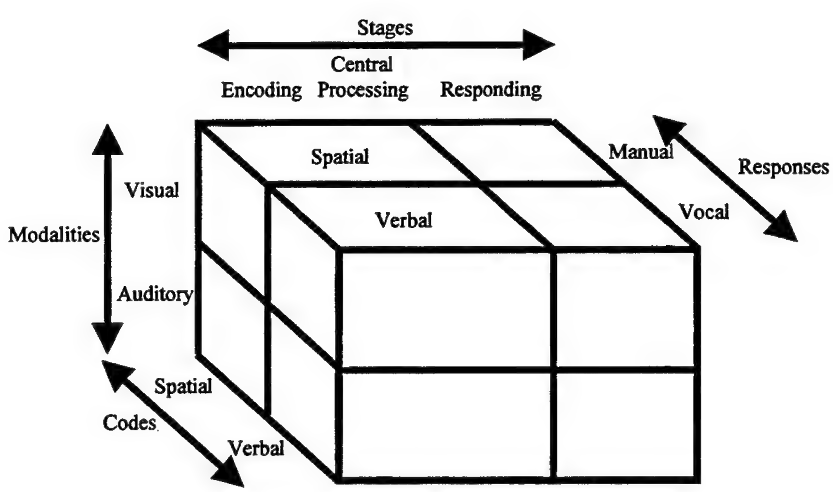

Figure 3: Model of Attentional Resources [WICK 84]

A study of the integrality of tasks [KRAM 85] clearly suggests situations where interference between concurrent tasks produced increased performance. Task integrality depends on inter-task redundancy, spatial proximity of displays, the degree to which tasks

are seen as operating on a single object, and the resource demands of the two tasks. Two closely integrated tasks can share processing resources and not cause the previously expected deterioration of performance.

Tasks are closely integrated if the nature of their stimuli are correlated, they depend on a common spatial location, or they operate on a common object (e.g., one task may operate on the shape of an object while another operates on its color) [DARK 93]. Applying this information to the development of VEs can help establish guidelines for how much and what types of non-integrated stimuli (stimuli directed from within the VE and unintended stimuli from the RE) an individual can handle before there is a dual task situation. It can also assist in designing VEs that incorporate integrated tasks that produce constructive interference to enhance presence.

Having an understanding of the various resource theories and how attentional resources are allocated in the dual task paradigm will help determine where certain display technologies fall on the proposed new scale. This idea will play a major role in the approach used in this thesis to measure presence.

III. APPROACH

One of the distinguishing features of a VE is the participant's tendency to respond to it as a place. While experiencing VEs, they can be heard saying "Where am I now?", "I'm lost", "What was that?", or "Lets go back to the 7-Eleven". Afterwards, their comments about their experience often start with the words "when I was there". "Here", "there", and "where" are spatial responses to a place that we are familiar with in reality. People may experience VEs as if they are really in a different place. Few other presentation media, theaters, television, books or music, can generate such compelling impressions of being in another place.

Because of the many, varied applications that VEs could be used for, it is essential that the ability to create VEs based on validated, quantifiable methods of predicting and measuring the resultant presence be developed. The goals of this thesis are to develop such a quantitative measure of presence and to use this measure to evaluate the effect of visual and aural displays on presence.

This chapter describes a proposed measurement of presence, how it was developed, and the variables which are believed to influence the degree of presence users experience when interfacing with VEs with respect to specific VE displays or combinations of displays.

A. PROPOSED MODEL

The proposed model was designed to evaluate the effect of visual and aural displays on presence using the dual task paradigm of attention theory. The commonly used method for measuring presence is a subjective self-assessment provided by questionnaires completed by the user following their VE experience. In order to create an

objective assessment, written tests were developed that included specific questions regarding the VE and the RE and a video that played nearby in the experimental area. This was done speculating that the answers would indicate whether the participant's attention was focused on the demands of the VE or on the real world video and environment.

Our senses are basically like antennae that are continuously processing stimuli. The process of focusing our attention is dependent on several key elements. In the case of VEs, these elements include interaction, content, sound, FOV, fast update rate, head tracking or mapping, high image complexity, and the resources needed to fill the demand for task performance (attending)(Table 1).

ATTENTION	
Interaction	Fast update rate
Content	Head tracking/ mapping
Quality sound	High image complexity
Large field of view	Fidelity

Table 1: Key Elements of Presence

The goal in creating the model was to provide two separate environments that produced their own stimuli and to either include or exclude sound associated with the environment (Figure 4). Producing competing demands for stimuli caused participants to have to allow their processing system to help focus their attention on one or the other environment or to divide their attention between the two. Another aspect of the experiment was to specifically tell one group of participants to try to focus their attention

on both sets of stimuli simultaneously. The other group was not told to intentionally focus but were allowed to naturally apply their attention resources to the task.

Vision is the primary modal domain. Therefore, the model was created to provide three different types of visual display, varying degrees of field of view, resolution, and update rate.

In order to determine the importance that aural stimulation has on presence, the model provided sound for one group and no sound for the other group.

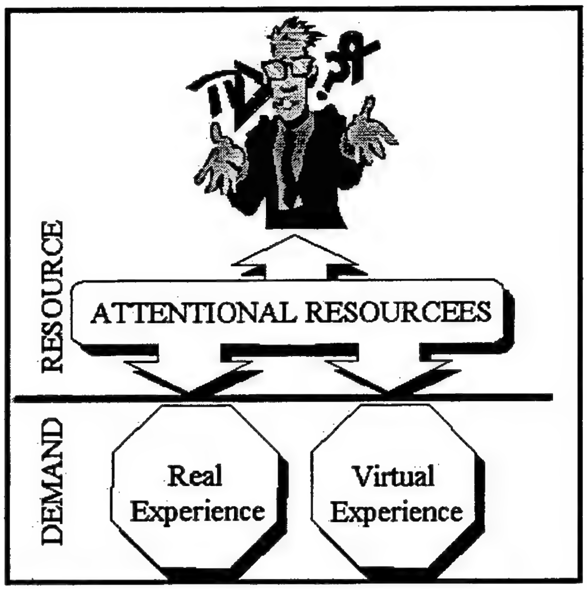

Figure 4: Division of Resources

The tests that were developed asked questions that were both subjective and objective. Questions regarding details of both environments required very specific answers. In order to analyze where the participant's attention was focused at any given time, the questions were designed to correlate one environment with the other within specific periods of time.

Working within the dual task paradigm of attention theory, the goal was to understand what quantity, quality, and combinations of displays are required to

disconnect or disengage the participant from the RE, if the sense of disconnectedness seems complete or fractional, and for what periods of time the participant remains disconnected. In addition, we were interested in whether any events from the RE might be absorbed and integrated as a part of the VE.

B. HYPOTHESES

The following hypotheses for this experiment are as follows:

- Given three different visual display technologies, individuals using a head-mounted display (HMD) will experience a greater level of engagement than those using three screen TV (3-TV), which will have a greater level of engagement than those using a flatscreen (FS) monitor.
- Given three different visual display technologies individuals receiving sound cues will experience a greater level of engagement in all three different visual display technologies than those without sound cues.

The sub hypotheses for this thesis are the following:

- Those participants who have higher presence scores on the PQ will have a higher VE score.
- Those participants who have higher immersive tendencies (ITQ) will score better in the VE than those who do not, with display characteristics being unchanged.
- Those participants who are primed to attend to the RE will have lower VE test scores and higher RE scores than participants who are unprimed.

These hypotheses were drawn by evaluating three different visual displays with and without aural input using the four display requirements suggested by Steuer; Inclusive, Extensive, Surrounding, and Vivid discussed in detail in chapter II under Immersion. Flat screen with no aural stimulation provides the smallest FOV and, therefore, the greatest exposure of the display equipment and loss of the illusion of non-

mediation. Flat screen only provides the most limited modal stimuli of the displays within the given parameters of the experiment and provides only low fidelity. Combining flat screen with aural stimuli does increase the range of modalities stimulated and should thus increase the attention of the participant. Three-screen with no audio has the potential to provide more energy to cognitive awareness than the flat screen with audio due to the greatly increased FOV and the increased illusion of spatial depth which, for most people, appear to play an important role in the sense of "being there". Three-screen with audio provides the greatest FOV and input from the modality believed to provide the second most important stimuli. The HMD enhances the VE in large measure. HMD provides quality resolution, more spatial acuity and disallows the participants ability to see the display and RE surroundings, therefore, increasing the illusion of non-mediation. HMD with the added stimuli of the aural sense increases the range of stimulation, fidelity, and energy of the experience. The important information was to analyze in what order each of the combinations of displays measured on the proposed scale.

Our hope is that this scale will provide a solid method of measuring the resultant level of presence with the use of these particular displays and encourage further development of the scale including all VE technologies available.

C. PROPOSED SCALE

When trying to conceptualize a scale to measure presence, a generalized scale was the first to occur (Figure 5). Comparing presence on a small scale such as what occurs when reading a book to the level of presence that is hoped will be achieved in VEs is relatively easy to imagine. There are, of course, variances due to differences in individual's interests and tendencies of involvement.

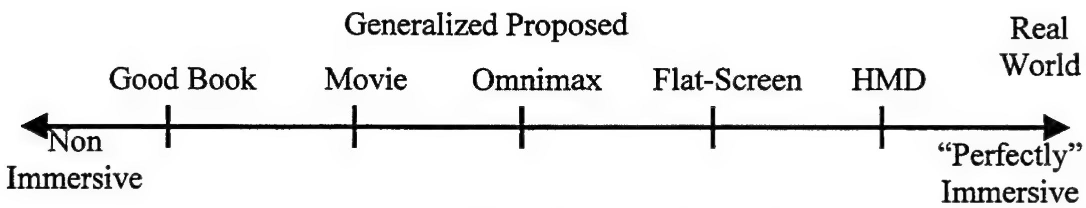

Figure 5: Generalized Proposed Scale

The scale for presence within the parameters of this study are virtually the same having information pertinent to VEs only (Figure 6).

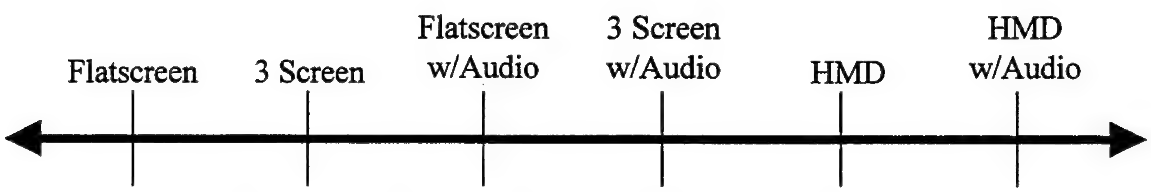

Figure 6: Proposed Scale with Predicted Outcome

The hypotheses of this thesis lead to the prediction that flat screen with no audio would be placed at the lowest level of presence within the specified parameters. Flat screen with audio would probably be next but it was speculated that three screen with no audio may actually be equivalent to or less than the flat screen with audio, taking into account the previously explained necessity for aural stimuli that is often overlooked. Three screen with audio is next, followed by HMD with no audio and finally at the high end of the scale, HMD with audio. The actual distance between each was not considered in creating this scale.

IV. METHOD

A. EXPERIMENTAL DESIGN

The experiment was a 3 x 2 x 2 factorial design. The three factors were (1) type of visual display, (2) absence or presence of sound, and (3) directives to attend to the RE. The three levels of the first variable were a flat screen (FS), 3TV screen (3TV), and head-mounted display (HMD). The two levels of the second variable were the use or nonuse of generated sound. The two levels of the third variable were whether or not directives were given to the participants to attend to the RE (primed or unprimed).

	SOUND		***NO SOUND***	
	PRIMED	***UNPRIMED***	***PRIMED***	***UNPRIMED***
HMD	5	4	5	4
3TV	5	4	5	4
FLATSCREEN	5	4	5	4

Table 2: 3 x 2 x 2 Factorial Design

The dependent variables (Table 3) represented responses to quizzes and questionnaires evaluating the participant's level of engagement within the VE and RE. Each quiz reported the level of information a participant remembered about the VE and RE as a function of each of the independent variables listed above in Table 2. The immersive tendency questionnaire (ITQ) measured the participant's immersive tendencies to become involved prior to the VE experience and the presence questionnaire PQ measured the participant's sense of presence within the VE [WITM 98]. The quizzes were used in an attempt to establish a quantitative measurement for engagement. However, when examining the validity of an objective measurement of engagement, the

questionnaires, which were subjective evaluations of presence, will represent the fundamental measure against which all objective mesasures will be assessed and standardized. VE-RE is the VE score minus the RE score which determines how engaged a participant was in a given environment. This score does not represent how much a participant remembered, rather, it measured where their cognitive effort lied. Spatial awareness represents the number of errors the participant made during their debriefing when asked to re-trace their route in the VE.

DEPENDENT VARIABLES	
VARIABLES	**MEASUREMENT IN PERCENTAGE**
Normalized VE Score	0 to 100
Normalized RE Score	0 to 100
VE-RE Score	0 to 100
Spatial Awareness	0 to 40
PQ Scores	0 to 231
ITQ Score	0 to 210

Table 3: Dependent Variables

B. PARTICIPANTS

Seventy participants (52 males and 18 females with average age of 37) participated in the experiment. The RE control group consisted of 6 participants, the VE control group consisted of 10 participants. These control groups were used to establish the baselines for the VE and RE quizzes. Prior experience with VEs varied widely and the participants were assigned to a group at random. The criteria used to qualify the participants was that they had not seen the RE video that was part of the experiment, they spoke and understood English well, and had normal or corrected to normal vision.

C. BASIC TASKS AND APPARATUS

The primary task in the experiment involved being a passenger in a VE vehicle and remembering as much detail as possible about the environment and about events occurring in the VE. A secondary task involved attending to a video being shown in the lab concurrently. The participants were placed in the corresponding experimental setup according to which group they had been assigned. The entire group was specifically given directives to attend to the VE and remember as much as possible. Only half of the group was told to also attend to the video and remember as much as possible.

There were three basic visual displays and each of the three were used either with generated sound or without generated sound. Figure 7 shows the exact amount of the visual field occupied by each condition. The three visual displays were a flat screen monitor (Left, Figure 7), three large television screens placed together in a semi-circle configuration (Middle, Figure 7), and a HMD unit (Right, Figure 7). The sound stimulus was provided by headphones for each of the three setups that included sound.

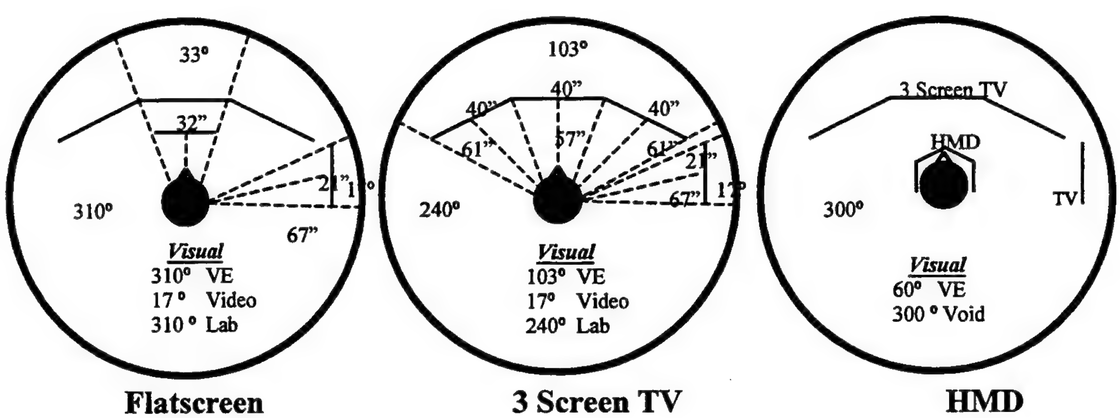

Figure 7: Visual Treatment Layout

D. MEASURES

According to Witmer and Singer, presence is a normal awareness phenomenon that requires directed attention and is based on the interaction between sensory stimulation, environmental factors that encourage involvement and enable immersion, and internal tendencies to become involved [WITM 94][WITM 98]. Questionnaires previously developed by Witmer and Singer for self-assessment following a VE were used for this study in order to attempt to correlate attention with presence in a substantive manner. The immersive tendencies questionnaire (ITQ) was developed to measure the capability or tendency of individuals to become involved or immersed. The presence questionnaire (PQ) suggests the degree to which individuals experience presence in a VE and the influence of other contributing factors on the intensity of this experience. Both questionnaires are subjective in nature and rely exclusively on self-assessment.

Speculating that the dual task paradigm of attention theory has a significant impact on presence, quizzes were developed for the VE and the RE. The questions were designed to be very specific in nature and the sequence of events were aligned so that analysis of the answers would indicate to which environment the participant was attending at various intervals.

Measuring spatial awareness in the VE is another component of attention theory that warrants future study. Spatial awareness has been defined for this thesis as an awareness of the location of objects in the immediate surroundings relative to one's location as a passenger in a car (egocentric perspective). Spatial information gathered by an individual is stored as spatial knowledge [WICK 92]. When the spatial environment to be learned is large and can be navigated, this spatial knowledge is often referred to as a

cognitive map. Studies have shown that environmental context (termed "landmarks" in large-scale environments) aids the development of spatial knowledge, whether that knowledge is of large- or small-scale environments [VENT 89][WICK 92]. Venturino and Kunze suggest that a large FOV will facilitate the development of spatial awareness because a larger view allows for easier integration of environmental elements and their associated relationships. It is also believed that a multiple target environment adversely affects the development and maintenance of spatial awareness. In consideration of these facts, participants were asked to actively drive through the VE by the same route that they had gone in the experiment. This was done to gather general observations about participant's spatial awareness, therefore quantitative measures were not gathered for analysis in this study.

Baselines were determined by the use of control groups. The purpose was to gather information regarding what could be expected of participants who had only experienced one environment or the other with no competing concurrent environment (see Figures 8 and 9). Just how well could they be expected to answer the questions? Test questions (pertaining to both RE and VE) completed following the VE experience were broken down into high, medium, and low importance. Questions that were answered correctly by the greatest number of participants were rated high. Medium was assigned to questions answered correctly by roughly half the participants and low was assigned to questions answered correctly by few or none of the participants. High rated questions were not of much significance because nearly all participants answered all of them correctly. However, medium and lows warranted some exploration as to what was going

on in either environment at a given place in time. The baselines were normalized so that VE and RE scores could be compared to one another.

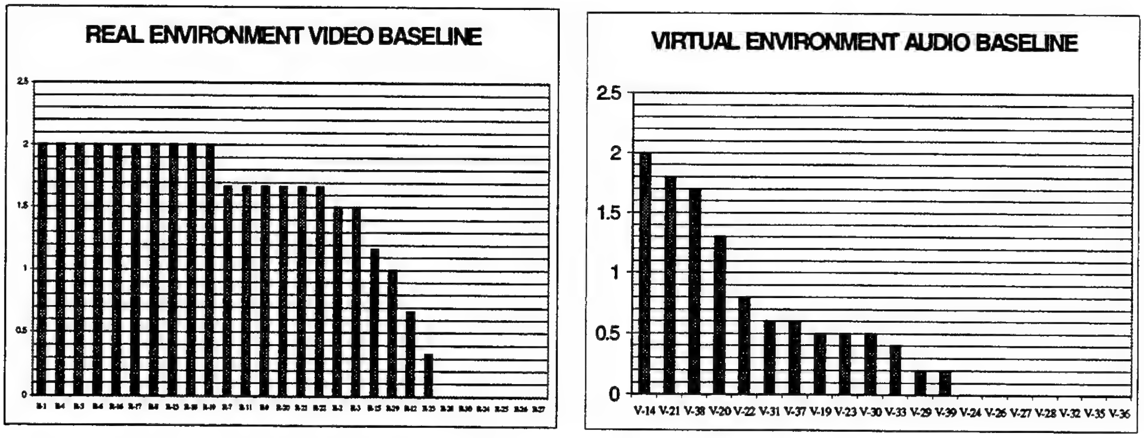

Figure 8: Virtual Environment Video and Audio Baseline (See Appendix E-2)

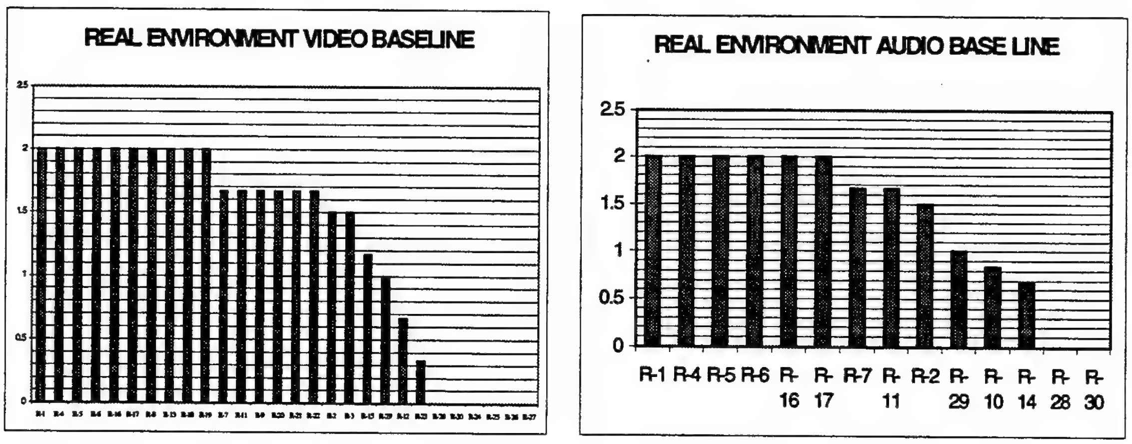

Figure 9: Real Environment Video and Audio Baseline (See Appendix E-3)

The baselines served as a reference point between the RE and VE control groups and each treatment. This provided a way to quantify a participant's attention within either environment at any given time. The baseline also provided a way to categorize visual and audio questions into high, medium, and low responses.

E. PROCEDURES

Step One: The experimental area was setup completely prior to each participant's arrival (See Appendix B). The participant was introduced to the experimenter and given a detailed in-brief (See Appendix C) in a location set apart from the experimental area. The participant was asked to read and sign the consent and privacy act forms (See Appendix D). The participant was then asked to complete a pre-questionnaire (See Appendix E-1) and instructed to enter the experimental area when they had completed the pre-questionnaire and were ready to begin the experiment.

Step Two: Upon seeing the participant enter the area indicating their readiness to begin the experiment, the experimenter started the RE video. The participants in the half of the group that were given no directives to attend to the RE were seated and the experimenter continued working around the area leading the participant to believe they were simply waiting for the setup to be completed. The purpose of doing this was to observe how involved the participants would become in the RE video and what effects it would have on the VE experience and the ability to switch their focus of attention and/or share their focus of attention between the two without consciously doing so. The second half of the participants were seated and specifically directed to observe the RE video and remember as much as they could about both experiences. Approximately five minutes after the start of the RE video, the experimenter continued by explaining to the participant that the VE would involve them as a passenger in a car and that they would be asked to answer questions about the VE following the experience. After familiarizing and instructing the participants in the use of the displays used in the particular setup they

were assigned, the VE portion began. The VE experience lasted approximately 18 minutes.

Step Three: When the VE experience ended, the participant was removed from the experimental area. They were asked to complete the post experience questionnaire (See Appendix E-4) and given a debriefing which included a number of verbal questions regarding both environments (virtual and real)(See Appendix E-2 and E3) and asked in general how they felt physically.

Step Four: The participant was then taken back to the lab and asked to "drive" the car via the same route in which they had been taken as a passenger. The participant was asked questions along the way in order to gain more information about their spatial awareness in the VE. This environment was the same environment minus all the dynamic models and without the audio.

Because some of the participants were deeply involved in the RE video and wanted to see the end of the movie or parts that they had missed, they were invited to watch the remainder after all aspects of the experiment were completed. They were also given the opportunity to use any one of the devices to "play" in the VE for a brief period of time.

V. MODEL DEVELOPMENT

As stated earlier, ideally the model developed would have allowed participants some degree of interactivity by virtue of being able to drive the vehicle and control the direction or speed of movement through the VE. However, because the goal was to create a situation that would provide quantifiable, factual answers to test questions, the VE needed to provide information consistently for each participant. Control of the VE and the movement within had to be maintained by the experimenter. Due to this design constraint, the VE plot might be considered to be less engaging than the plot of the RE video.

A. CONTENT

The VE story line involved each participant as a passenger riding through a small town in a vehicle with a virtual driver that provided audio stimuli via an automated information script. The script indicated clearly to the participant that they were a visitor to a new area and the purpose of their visit was house hunting. The trip began at a secluded parking area on the outskirts of the town. As the experience progressed, the vehicle moved through gradually more engaging views and sounds. The vehicle enters the town and the climax of stimulation is reached with the help of the plot. The vehicle then returns to the outskirts of town, gradually decreasing visual and auditory stimulation along the way, until the trip ends where it initially began. Throughout the VE experience the automated script continued providing general information about the virtual town. This information was used, in part, to create the test questions to be answered at the conclusion of the VE.

Embedded within the automated script, radio broadcasts began to interrupt and announce a second, more engaging, plot. The second plot was an entertaining mock up similar to H.G. Wells' War of the Worlds. The broadcasts provided another source for test questions. Because the driver's script was automated, it showed no response to the second plot that was occurring and continued to navigate through the VE and provide the audio script. This caused a dual audio demand on the attentional resources of the participant that had to be processed.

The only movement under the control of the participant was with the use of a joystick for the flat screen and three TV screen, and head tracking for the HMD. The joystick and head tracking could only change the point of view by appearing to move the participant's head in different directions. Having the participant be a passenger in a car with an automated script provided a plot that remained in the experimenter's control and provided consistent information to each participant throughout the experiment.

B. HARDWARE

It was a very demanding task to configure a system so that the diverse needs of the application (management of input, simulation, display, audio) could be satisfied with adequate performance to keep the illusion from breaking.

The experiment utilized a variety of VE technologies to develop a wide range of visual stimuli and the presence or absence of audio stimuli. Some questions regarding the primary metaphor needed to be considered in order to select the appropriate hardware.

How was the participant to be represented in the VE? For the purpose of this experiment, the participant was represented as a passenger in a car (Figure 10). The direction and movement of the environment could be controlled by having the participant

be only a passenger in the car and guaranteed that each participant in the experiment received identical treatments in order to increase the validity of the experiment.

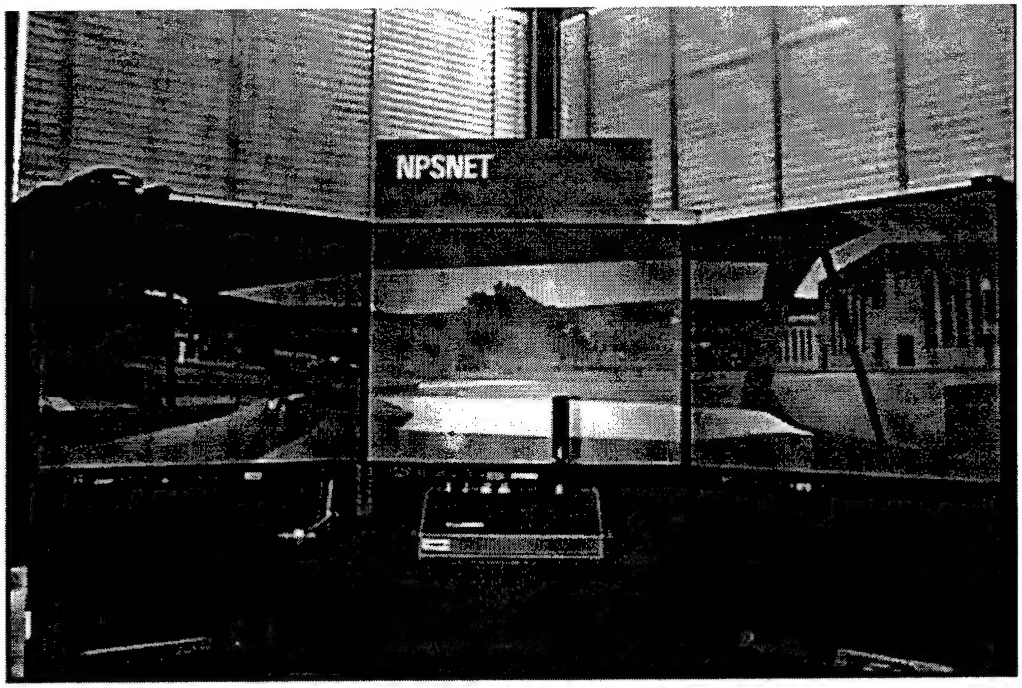

Figure 10: Passenger View From Car

What did the participant need to achieve and how was that accomplished? The participant needed to be able to describe the surroundings and the events that took place on the route traveled. This played a vital role during the debriefing. Therefore, the participant was given the ability to move their head as if they were traveling through the VE as a passenger in a car.

The participant was asked to complete a quiz that measured their objective level of engagement in the VE as well as the external RE. Afterwards, the participant was asked to complete a questionnaire that measured their subjective level of presence in the VE (see Appendix E). The selection of appropriate hardware was based on the decisions made in the previous step and the equipment available.

The first display type used in this experiment was a 21 inch Silicon Graphics color monitor. This monitor has 1280 x1024 pixel resolution with 50-76 Hz refresh rates (Figure 11, Left). The computed FOV with this screen when setup is approximately 33 degrees.

The second display type used in this experiment was three Mitsubishi Model VS5071, 40 inch, rear projection screens set in a semi-circular configuration (Figure 11, Right). The three screens were approximately sixty-seven inches from the participant, providing the user with a 103 degree FOV.

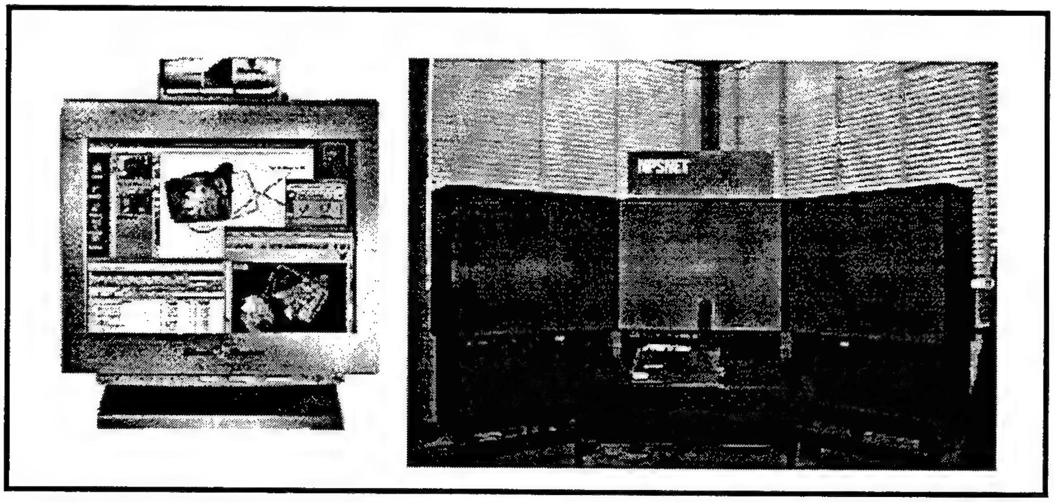

Figure 11: Silicon Graphics 21 Inch Monitor and Mitsubishi 40 inch TV

The final display type used in this experiment was a Virtual Research V8 head-mounted display (Figure 12). This HMD consists of active matrix LCDs with true VGA ((640x3)x480) pixel resolution. This HMD was chosen over the rest because of the pixel resolution, the lightness of the device, the ease of use, the durability and the fact it provides a FOV of approximately 60 degrees. The HMD is very comfortable using rear and top ratchets and a spring-loaded forehead rest. Adjustments are quick and precise. The interpupillary adjustment doubles as an eye relief adjustment to accommodate

glasses. This device was equipped with high performance earphones with swivel and rotation capability. These earphones were easily removed when the experiment did not involve sound.

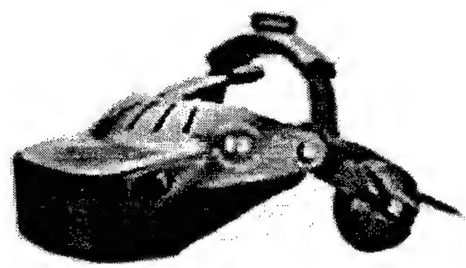

Figure 12: Virtual Research V8 Head-mounted Display

The inputs and outputs for audio, video, and power are handled through the V8 external control box. The red LEDs indicate Power On and Stereo modes. This box uses standard 15-pin VGA-type connectors which accept VGA (640 x 480 60Hz) inputs. Overall brightness and contrast adjustments are easily tuned from the front of the control box. External VGA monitors may be connected to the MONITOR OUT located on the control box.

Along with the quality of the graphics, an important criteria for the computers used for displaying the VE was the speed at which they render the images. This is referred to as the update rate. It is the speed with which the computer can calculate and render each new view. Although there has been no definitive study as to the minimum update to sustain the illusion of presence, most researchers agree that 15 frames per second (FPS) is an important threshold, below which the intervention of conscious awareness is often inevitable [ZYDA 97].

Since the database of these VEs are geometric models, the unit of measure for the speed of a computer is the number of polygons it can render per second. The polygon is a surface made up of three vertices (a triangle). Thus, a six-sided cube has 12 polygons. The greater the complexity of the model, the higher the polygon count. Small computers can render models made up of a few polygons many times per second, whereas faster ones can render millions of polygons per second.

The computer used for this experiment was an SGI Onyx RE-2 workstation. This workstation is equipped with an Infinite Reality graphics board, 128Mb of two-way interleaved main memory, 4Mb of texture memory, 1Mb of secondary unified instruction/data cache, four 194 IP25 MHz MIPS R10000 processors and an Iris Audio Processor version A2.

Considering the primary goal of this thesis was to measure the different types of immersive technology and the resultant presence they provide in VEs, the three different display types discussed earlier were all used on this workstation. The traditional 21 inch flat-screen display provides approximately 30 fps. This display was chosen to further explore the concept of desktop virtual reality. Desktop VE is when a large computer monitor or projection system is used to present the VE. Business and industry users find this useful due to the inadequacies and impracticalities of head-mounted displays. This type of VE system requires the user to use a position tracker and another manual device such as a mouse or joystick. These tools allow the user to view all 360 degrees of the VE through the window of a computer screen while seated in front of the monitor.

The three screen display provides 24 fps. This display was chosen to further explore the concept of why people become immersed in large screen TVs or in movie theaters. This type of display can also be placed in the category of desktop immersion.

The third display used was a head-mounted display which provided between 18-24 fps. Wearing the display on one's head provides a greater sense of immersion. Researchers speculate that this is because the user's visual perception is bound to the images presented by the computer in the HMD. The intention is to focus the user on the VE, so that they can interact with the VE just like they would in reality. However, the quality of today's commercial products is still relatively poor compared to the resolution from a flatscreen display and/or even the FOV from a large screen TV on projection. This device was ideal for the purposes of this study as the user's action volume was protected because the user was a passenger sitting in a car seat. Stereoscopy can either be neglected (in that case the same input is presented to both eyes), or two input signals are necessary. These can be provided by two separate image generators (either two graphics boards in one computer, or two computers that are synchronized over a network). Two signals can also be generated by special graphics boards (like the SGI multi-channel option), but this solution is often prohibitively expensive. For this reason, the same input was presented to both eyes in this experiment. HMDs normally include a head-mounted tracker, so that the user is always presented with an image according to the current head position and orientation.

The tracking system selected for the HMD was the 3Space Polhumus Fastrak (Figure 13). This device accurately computes the position and orientation of a tiny receiver that is mounted on the HMD as it moves through space. It virtually eliminates

the problem of latency as it provides dynamic, real time six degree-of-freedom measurement of position (X, Y, and Z Cartesian coordinates) and orientation (yaw, pitch, and roll), and it is the most accurate electromagnetic tracking system available.

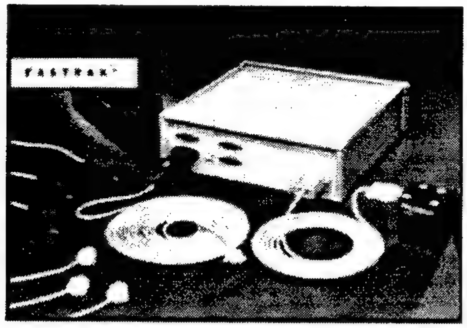

Figure 13: Polhemus FASTRAK

Because of the close proximity of the participant to the HMD control equipment and the somewhat limited movement of the participant, this device was the perfect solution for interfacing with the VE and controlling the user's head movements. The bulkiness of the HMD wiring had less affect on an object that had restricted movement. The HMD enabled the view of the RE surroundings to be occluded. This device utilizes a single transmitter and can accept data from up to four receivers. The use of advanced digital signal processing (DSP) technology provides an update rate of 120 Hz (with a single receiver) and a very low 4ms latency. This data is then transmitted over a high speed RS-232 interface at up to 115.2Kbs per second. In this experiment, the data was transmitted at approximately 38Kbs per second.

The second input device considered for the experiment was the BG Systems FlyBox (Figure 14). The FlyBox is a high quality integrated joystick input device that interacts with the computer. It consists of a three-axis joystick (yaw, pitch, and roll), two levers, eight discrete push buttons, and a trigger on the joystick. The FlyBox provides

input to the computer through the serial port, and is used with the flatscreen display and the 3TV display. Because this device is a commonly used tool for navigating VEs and it was familiar and comfortable to the designer of the VE, its use proved beneficial when recording multiple events in the 3-D model. It was easier to drive and fly vehicles in three dimensions with a three dimensional device than with the traditional mouse or keyboard input for recording.

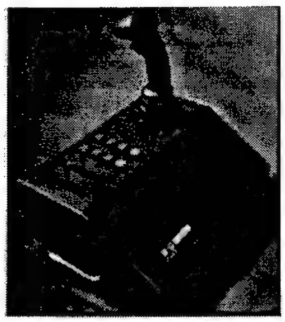

Figure 14: BG Systems Flybox

It may sound trivial in the age of "plug-and-play", but devices such as HMDs, Polhemus devices, Flyboxes, and 3TV displays are still complicated to integrate into such a system. This is partly due to the limited distribution of VE devices and a lack of standards. This will certainly improve over time, but for now the process of integration is not straightforward. It may be necessary to create custom device drivers that have specific properties, or run under specific software configurations or flavors of operating systems. Even if the drivers supplied by the vendor can be used, it may be necessary to fine-tune the parameters that can be set for the device (sampling frequency, sensitivity etc.). This was the case with the Polhemus Fastrak device and BG Systems Flybox.

C. SOFTWARE

Once the major design issues were resolved, it was necessary to define an implementation strategy. Considering the different types of immersive input and output device technologies, it became necessary to decide on the software support needed to bring this VE together. VEs can be very complex as well as the software used to implement these systems. It is necessary to fine-tune any part of the VE application so that the high performance demands of an immersive application are met. The dilemma can partly be resolved by the use of toolkits that support a well-defined aspect of the VE and are highly optimized for the task. The same toolkit should provide features for creating the 3D images (rendering) and for supporting the devices (device drivers in the broadest sense). Unfortunately, it may not always be possible to extend, modify, or patch the commercial toolkit to implement the desired environment or device usage. The highest level of support comes from integrated software solutions. However, the set of features supported by such a closed solution is fixed, and it may often fail to support all desired designs.

For the VE development, the toolkit developed by Coryhpheaus Software (Designer's Workbench, EasyTerrain, and EasyScene) and Multigen were used. Multigen and Designer's Workbench (DWB) are interactive, 3D modelers optimized for creating real-time visual simulation databases. The standard Multigen and DWB systems include an extensive suite of texturing tools and editors, 3D direct manipulation interface, and "drag and drop" editing. Multigen and DWB's Real-Time Animator (RTA) was used for defining and verifying dynamic behaviors to the database elements of the models. The main behaviors used in this model were rotor movements, tank turret movements, smoke,

and fire. The DWB RTA provided the ability to build these fully articulated 3D models and animate dynamic features of the models all from within the 3D modeler. These dynamic objects were tested and optimized in the modeler using external data sources to directly drive the objects with real-time data from data files.

Performer Town from Silicon Graphics, Inc. was the base model for this VE. EasyTerrain was used to modify Performer Town to create a fully textured 3D polygonal database suitable for the VE. EasyTerrain provided the necessary tools to create and modify pieces of the terrain.

EasyTerrain has the ability to convert Defense Mapping Agency (DMA) Digital Terrain Elevation Data (DTED) and U.S. Geological Survey (USGS) Digital Elevation Models (DEM) data into fully colored and textured polygonal models and maps. Easy Terrain can both generate a large number of levels of detail (LODs) and partition the model, structuring the database for optimal culling by the image generator, guaranteeing true edge coherency between sectors and files.

EasyScene loads terrain databases built in EasyTerrain and model databases built in DWB as well as databases generated in several other formats (Flight, DXF, Wavefront). Fully articulated models, such as those used in this VE (e.g., tanks, planes, fires, and smoke) or dynamic instrument displays defined with the DWB RTA work automatically in EasyScene. This feature made articulating models, Heads-Up-Displays (HUDs) and other applications quick and easy to develop without any programming. EasyScene handles typical image generator functions such as LOD switching, frame rate locking, weather, special effects (fire, smoke, explosions, trails, etc.), scene management, terrain following, and collision detection. Some of EasyScene's other capabilities include

support for multiple channels used in the three different display types, multiple CPUs used for APP, CULL, DRAW, 3D audio support, and easy integration with user programs via library routines. EasyScene allows for flying, driving, or walking through models at different times of the day and under varying weather conditions. EasyScene provided record/playback features that were instrumental for modeling events in chronological order.

D. TESTING THE SYSTEM

Probably the most important aspect of developing the VE was the number of iterations the VE underwent. During this phase of the VE development, a pilot study consisting of approximately 30 participants was conducted. In the course of the pilot study, changes to the environment were completed after each set of four or five participants had provided feedback regarding their experience. This provided the necessary information to fine-tune the environment and create a VE that was more captivating and interesting to a greater number of participants.

VI. ANALYSIS

A. INTRODUCTION

This chapter reports the results of an experiment that investigated the level of presence or engagement in one experience as a function of disengagement from a concurrent experience. Dependent measures for each treatment include quizzes for the VE and RE, the immersive tendency questionnaire (ITQ), and a presence questionnaire (PQ). Participants were evaluated on their quiz and questionnaire scores.

The two quizzes were used to measure attention in the VE and the RE. Each question answered correctly received two points, a partially correct answer received one point, and a wrong answer received zero points. Scores were then normalized in order to make comparisons between the VE and the RE.

B. POWER ANALYSIS

The tests reported here are three way analysis of variance (ANOVAs) between displays, the absence or presence of sound, and whether or not the participants were primed to attend to the RE. The sample size was seventy participants. An α of 0.05 was used, resulting in a power value ($1-\beta$) of 0.2095. Consequently, the ability to detect alternative hypotheses is relatively poor. This suggests that drawing any conclusions based exclusively on a failure to identify a positive effect on any factor is imprudent.

C. PRIMARY RESULTS

1. Primary Hypothesis:

Given three different visual display technologies, individuals using a head-mounted display (HMD) will experience a greater level of engagement than those using three screen TV (3-TV), which will have a greater level of engagement than those using a flatscreen (FS) monitor.

An objective comparison can be made between treatments of engagement in the VE versus the RE by measuring the difference between the two quiz scores. Figure 15 shows the VE-RE scores for the three display treatments. In all but four cases, VE scores were greater than RE scores because the VE task was viewed as the primary task per the instructions given to each participant. A higher number means greater engagement in the VE versus the RE.

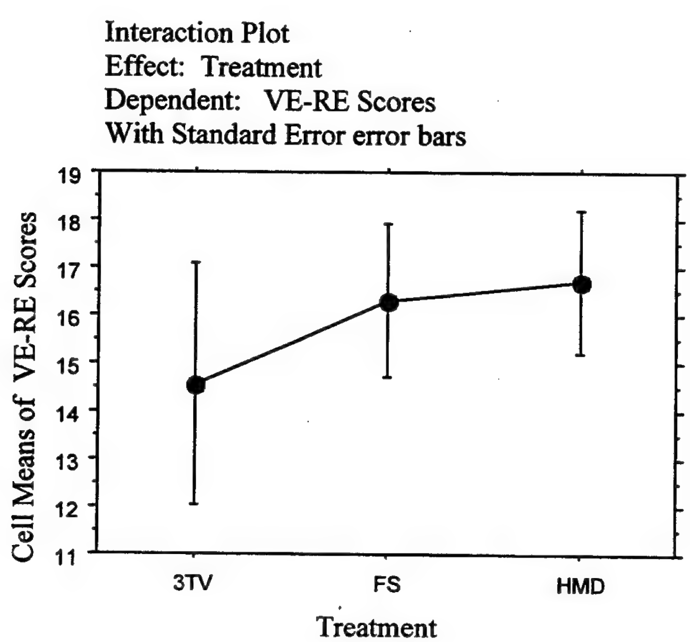

Figure 15: Treatments vs VE-RE Scores

Although the results in this case are inconclusive, $F(2, 42) = 0.331$, $\underline{P} = 0.7204$, note that the HMD has the highest level of engagement with FS and 3TV following. The interesting point is that FS is not only greater than 3TV, but almost as high as HMD. Although no definitive conclusions can be drawn from these results, direct observation suggests that because the HMD occluded all of the RE, scores were higher than the FS and the 3TV conditions in the VE. It follows that the FS and 3TV conditions would be lower than the HMD because they could not occlude the RE, but why is FS higher than 3TV? This result suggests that the FS was a more challenging task due, in part, to a narrow FOV requiring excessive re-coding of information which increased the amount of cognitive effort involved in the task [WICK80], therefore, increasing the participants' level of engagement.

Although the results of the comparison above were inconclusive, let's look at the results from a different point of view. Consider an objective comparison between the three treatments using strictly normalized VE and normalized RE scores separately. This gives us an idea of how the different treatments affected the participant's level of engagement in each environment separately. The first comparison (Figure 15) clearly indicates HMD is the display that produces the highest level of engagement in the VE when viewed concurrently with the RE. However, a comparison between the three treatments based only on the VE scores obviously indicates that 3TV is the treatment that produces the highest level of engagement in the VE followed by FS and HMD (Figure 16). These results are the exact opposite when compared to the VE-RE scores. A higher score means greater engagement in the VE.

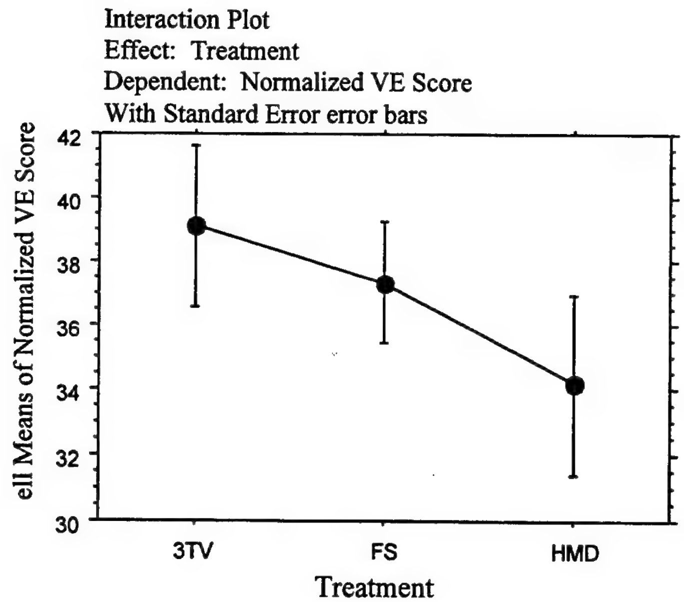

Figure 16: Treatments vs Normalized VE Scores

Even though the results in this case, as well, are inconclusive, F(2, 42) = 1.671, P = 0.2003, note that the 3TV has the highest score in the VE with FS and HMD following. These results contradict with the comparison of treatments versus VE-RE scores in Figure 15 measuring where the cognitive effort of the participants lied. Direct observations and a review of the videotapes on each experiment suggest that participants using the 3TV scored higher on the VE quiz because of the FOV, hence, providing the participant an informationally richer display medium than the other two display devices. Theory suggests that the reason participants' VE test scores on the FS were higher than the HMD was because the demand for attentional resources is higher when trying to focus on the smaller FOV. It is simply a harder task. Therefore, additional attentional resources are allocated to the more challenging task, increasing the participants attention in the VE. The HMD is a more natural device in terms of seeing and navigating the environment. Therefore, it demanded less attentional resources, resulting in a low VE test score.

Since the comparisons between the participants' level of engagement in the VE was completely inverted on their reported VE scores with respect to each treatment, an examination of the relationship between the different treatments and normalized RE scores is needed. An objective comparison of engagement in the RE can be made between treatments via the RE quiz scores. Figure 17 shows the normalized RE scores for the three display treatments. A higher score indicates greater engagement in the RE.

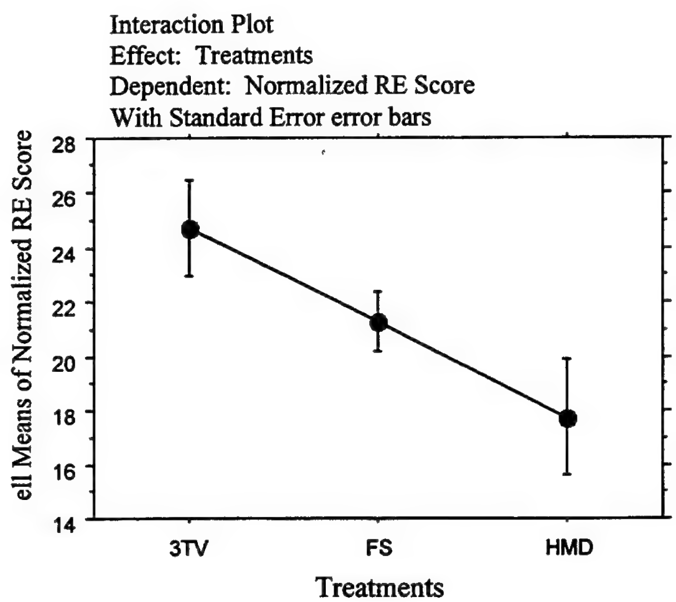

Figure 17: Treatments vs Normalized RE Score

The ANOVA indicates high significance, $F(2,42) = 6.771$, $\underline{P} = 0.0028$, between the different display devices and the participants' RE scores. These results indicate that the HMD occluded the RE preventing the participants from dividing their visual attentional resources between the VE and RE, consequently scoring lower on the RE quiz. However, it is extremely interesting that FS scored lower than 3TV on the RE quiz suggesting that the participants' attentional resources were not as easily divided as the 3TV. Therefore, the participants using the FS allocated more attentional resources to the

task in the VE, reducing the participants' available resources for the RE. The 3TV scored the highest on the RE quiz. It also scored highest on the VE quiz. Since the 3TV provides a much greater FOV and an information rich display medium, this enabled the participant to reduce the attentional resources demanded by the VE. Reducing the resources needed for the VE enabled the participant to increase their attentional resources allocated to the RE. Notice that these results support those that show the HMD has the highest level of engagement in the VE followed by FS and 3TV. Note also, that these results mirror the results of treatments versus VE scores. This warrants further examination of the treatments versus the composite normalized RE scores and normalized VE scores (Figure 18).

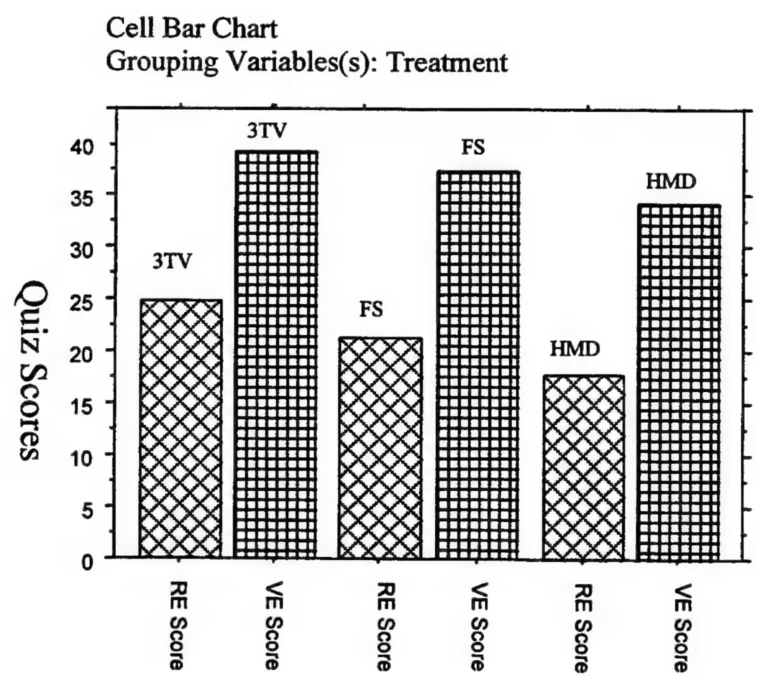

Figure 18: Composite between Normalized RE Scores and Normalized VE Scores

Of particular interest is the fact that 3TV has the highest level of engagement in both the RE and the VE based on the quizzes. This suggests that somehow participants are able to focus, engage and be aware of events occurring in the environments

concurrently. The fact that the 3TV has the largest FOV of the three displays has a great significance in this matter. Participants are able to comfortably scan the visual field of the VE with little need to focus directly on any one small area of view. Because the visual stimulation in the VE is easy to absorb and process, resources from the same pool can be allocated to the RE to adequately process information concurrently from both environments.

The FOV for the FS is also a significant factor in the fact that it was the second highest scoring treatment in the composite between VE and RE scores (Figure 18). Participants were required to focus more attention to the FS because of the small FOV causing the VE to become the dominant task. Because it was the primary task, the scores for the VE were higher than the RE, yet they did not correspond to the 3TV scores. This was due to the fact that the cognitive effort of allocating a greater amount of resources to the small FOV for the VE reduced the overall efficiency of task performance in both environments.

The HMD scored the lowest on both quizzes. The reason for having the lowest score for the RE is obvious. The RE was greatly occluded. Therefore, much of the information that the quizzes were based on was not provided to the participants using the HMD. The question then becomes, why is the HMD lower than FS and 3TV in the VE? In the earlier comparison between treatments and the VE-RE scores, it is indicated that the participants using the HMD had the highest level of engagement in the VE within the given parameters of the three treatments. This makes it obvious that they were engaged in the VE because the difference in VE versus RE scores is the greatest. However, overall, the HMD treatment scored lowest on both the VE and RE with 3TV scoring the

highest on the VE and RE. We can only conclude that the 3TV condition allowed for more information from both VE and RE to be attended to in a salient fashion whereas this was not the case for the HMD. Also, because the amount of cognitive effort required by the FS condition to attend to the VE was quite significant, they had to allocate greater resources to the VE.

2. Secondary Hypothesis

Given three different visual display technologies individuals receiving sound cues will experience a greater level of engagement in all three different visual display technologies than those without sound cues.

An objective comparison can be made between sound and no sound in the VE by measuring the difference between the VE and RE quiz scores. Figure 19 shows the VE versus the RE quiz scores for the use or nonuse of sound. In all but four cases, VE scores were always greater than RE scores because the VE task was viewed as the primary task. A higher number means greater engagement in the VE versus the RE.

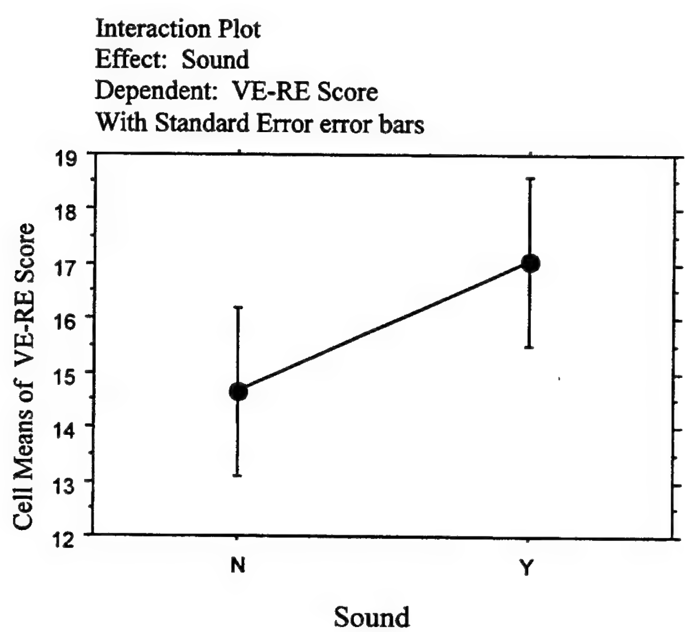

Figure 19: Sound vs VE-RE Scores

Although the results in this case are inconclusive, F(1, 420) = 1.103, P = 0.3414, note that introducing sound into the VE increased the participants' level of engagement in the VE. These results concur with numerous studies ([GILK 95] [SLAT 93] and [HEND 96]) indicating that sound plays a distinct and vital role in increasing the sense of presence in VEs.

Again, looking at an objective comparison between the presence and absence of sound and the normalized VE quiz scores, Figure 20 shows the scores for the VE with and without sound. A higher number means higher score on the VE quiz.

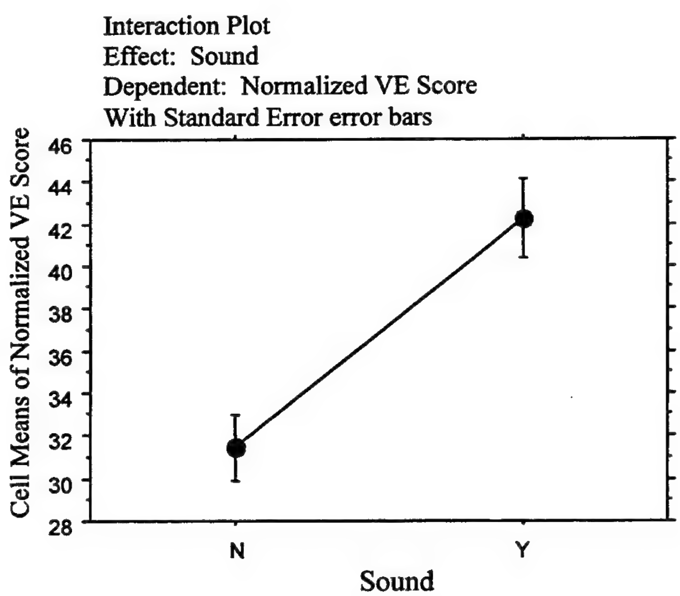

Figure 20: Sound vs Normalized VE Scores

The results are strongly conclusive, F (1, 42) = 18.846, $P \leq .0001$, between the presence of sound and the participants' normalized VE scores. These results are important because they further support past results of various research efforts such as [GILK 95] and [HEND 96a] that point to aural stimuli as being vital to presence.

Including sound in display designs can be considered of great importance if trying to reach a high level of engagement in a VE.

Taking into consideration the earlier results of comparisons drawn between VE-RE scores and levels of engagement and the similarities when compared to the results of VE levels of engagement and the presence of sound in the VE, we further investigate the relationship between sound and the normalized RE scores. Figure 21 shows the normalized RE scores for the use or nonuse of sound. A higher number indicates a higher score on the RE quiz.

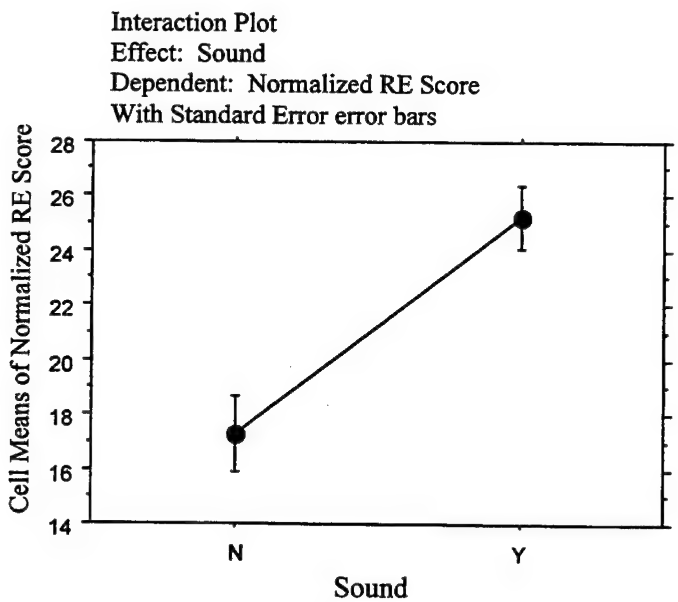

Figure 21: Sound vs Normalized RE Scores

Once again, the results are conclusive, $F(1, 42) = 28.387$, $\underline{P} \leq 0.0001$. The results show high significance between sound and the RE quiz scores. This suggests participants given sound were able to divide their attentional resources between concurrent tasks. Therefore, participants may have allocated their aural resources to the VE and their visual resources to the RE or vice versa. By stimulating two sensory modalities concurrently, it

increased the level of cognitive activity, thereby increasing the allocation of attentional resources from both pools and making it easier to perform both tasks concurrently [HIRS 87]. Participants who did not receive sound experienced a dual task conflict in the visual modality. When no sound is present it becomes necessary to divide the visual modality between both environments in order for the participant to perform both tasks, hence increasing the demand from the same resource pool and reducing the efficiency in attending to both tasks.

When we look at the results of the comparisons between the N-VE score and the presence of sound along with the results of the comparison between the N-RE score and the presence of sound we see quite conclusively that sound has a very profound effect on the level of engagement in both environments (Figure 22). Having such an effect on the VE seems rather obvious, but are the reasons for this as clear in regards to the RE? Why would having computer generated sound pertaining to the VE have a beneficial effect on the RE as well?

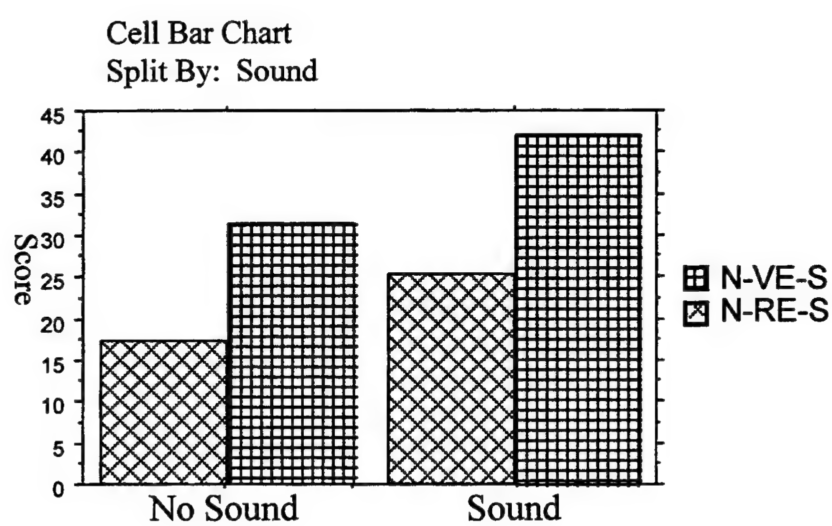

Figure 22: Composite between Sound and N-VE Scores and N-VE Scores

These results suggest that this is a clear case of resources being allocated from separate pools [WICK 84]. These results further suggest that allocation from two separate pools enabled participants to focus the visual modality on the RE while the sound pertaining to the VE provided a large amount of information needed to keep some degree of attention focused in the VE without a great deal of effort.

3. Sub Hypotheses

First Sub Hypothesis: ***Those participants who have higher presence scores on the PQ will have a higher VE score.***

In order to discover if participants' subjective self-reports of presence correlate with the VE quiz scores, an objective comparison was made between the PQ scores and the N-VE scores (Figure 23).

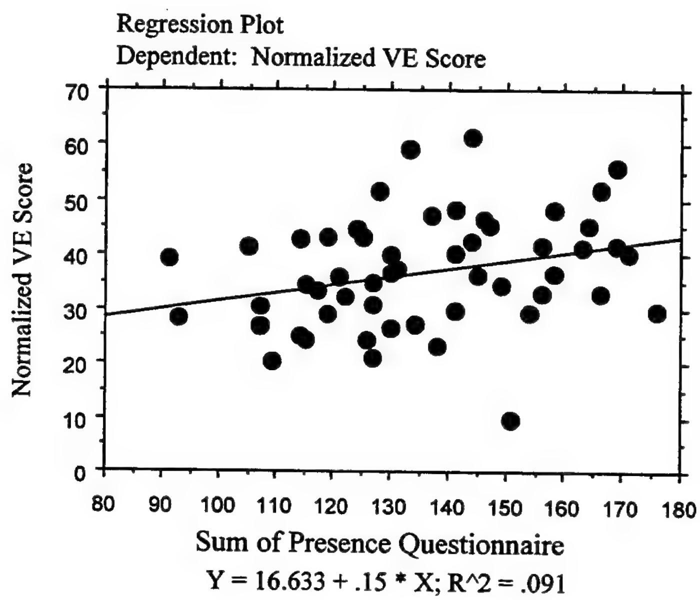

Figure 23: Correlation between PQ and Normalized VE Scores

As it pertains to this study, these results integrate the various comparisons throughout the study and show conclusively, F (1,52) = 5.191, P = 0.0026, that a

quantitative measure for engagement in VEs is, indeed, possible. At least this shows that the attentional resource paradigm used in this thesis has validity. The results of this particular comparison were expected based on research conducted on the PQ by Witmer and Singer [WITM 98]. The results clearly indicate a strong correlation between participants' self-reports of presence in the VE via the PQ and their VE scores on the quiz following the VE experience. It should be pointed out that two particular exceptions to these results were observed. Two participants reported high levels of presence via the PQ and observations noted during the experiment indicated that these two participants were very involved in the VE and clearly enjoyed the experience. Yet, they both scored poorly on both the VE and the RE quizzes. This suggests that participants can be present in an environment and still not be engaged, at least by the measures used here. However, this may also have been a situation where participants did not take the quizzes seriously or were possibly struck by the novelty of the VE, and consequently, little can be gained from this.

Second Sub Hypothesis: ***Those participants who have higher immersive tendencies (ITQ) will score better in the VE than those who do not, with display characteristics being unchanged.***

An objective comparison was made between the ITQ scores and the VE scores postulating that individuals who report a greater tendency to engage in normal activities will also have a greater tendency to engage in a VE (Figure 24).

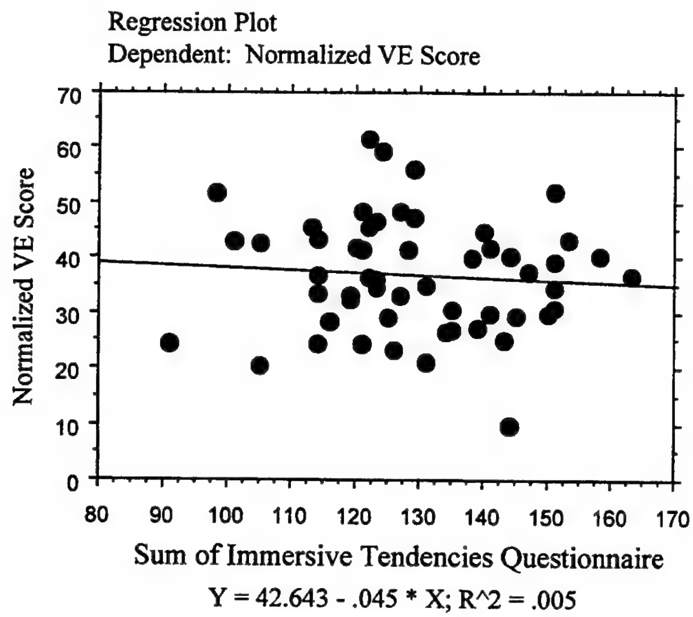

Figure 24: Correlation between ITQ and Normalized VE Scores

These results are inconclusive, F(1,52) = 0.246, P = 0.6220, and do not show significant correlation between normalized VE scores and ITQ scores. In hind sight, the results are not surprising when considering the studies conducted by Witmer and Singer [WITM 98] that pointed to a lack of correlation between PQ and ITQ scores. Although VE scores do correlate with PQ scores in this study, the lack of correlation between PQ scores and ITQ scores in Witmer and Singer's study would likely result in no correlation between ITQ scores and VE scores in this study, which is true in this case. Consequently, this is not considered a major failing in this experiment.

Third Sub Hypothesis: ***Those participants who are primed to attend to the RE will have lower VE test scores and higher RE scores than participants who are unprimed.***

This study also provided a comparison between primed and unprimed participants. The first comparison is made between primed and unprimed participants

and the level of engagement in the VE (VE-RE scores). Figure 25 shows the VE-RE scores for participants directed to attend to the RE (primed) and those not directed to attend to the RE (unprimed). In all but four cases, VE scores were always greater than RE scores because the VE task was viewed as the primary task per the instructions given to each participant. A higher number means greater engagement in the VE versus the RE.

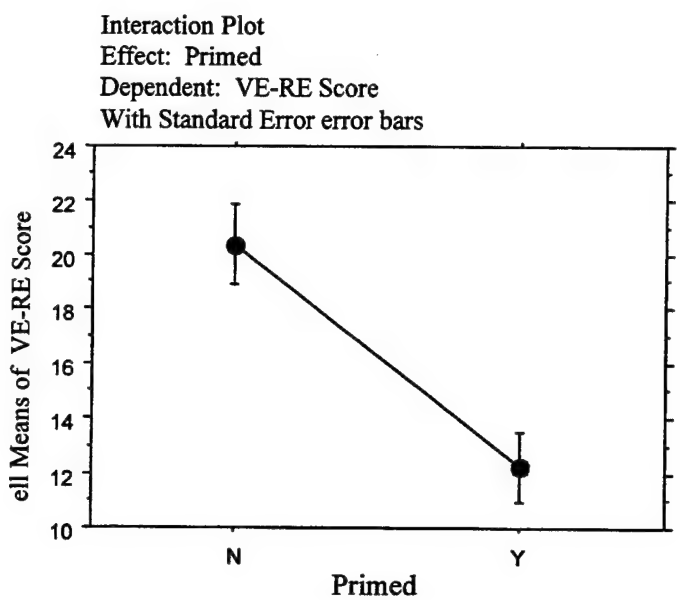

Figure 25: Primed vs VE-RE Scores

The results are conclusive, F(1,42) = 16.389, P = 0.0002, between participants who were primed versus participants who were unprimed. These results suggest attentional resources allocated from the same pool caused some degree of deterioration in task performance for the primed participants. It follows that unprimed participants would experience a greater degree of engagement in the VE because they were not directed to actively attend to both tasks concurrently. Therefore, they focused their attentional resources on the VE which was viewed as the main task.

The next step in this comparison involved primed versus unprimed participants and the VE quiz scores. Figure 26 shows the normalized VE scores for primed and unprimed participants. A higher number indicates a higher VE quiz score.

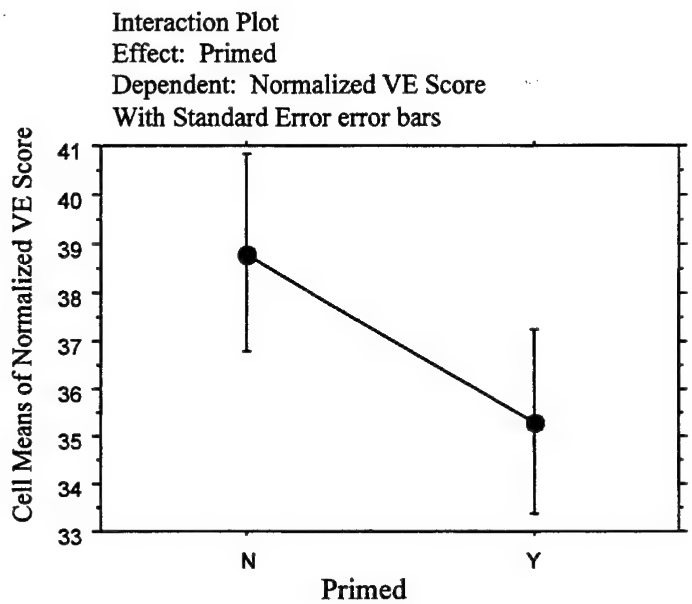

Figure 26: Primed vs Normalized VE Scores

Although the results are inconclusive, F (1, 42) = 2.026, P = 0.1620), unprimed participants scored higher on the VE quiz. Observations and videotapes show participants who were unprimed focused very little attention to the RE video during the VE experience. Those who were primed tended to shift their vision between the VE and the RE video. This suggests that primed participants' were consciously directing attentional resources to two concurrent tasks causing deterioration in attending to the VE but increasing the ability to attend to the RE. By directing resources away from the VE, primed participants exhibit lower VE scores.

This would indicate that a comparison between primed or unprimed participants and the scores in the RE will also indicate deterioration of attending to the VE while ability to attend to the RE increases for primed participants and decreases for unprimed participants (Figure 27).

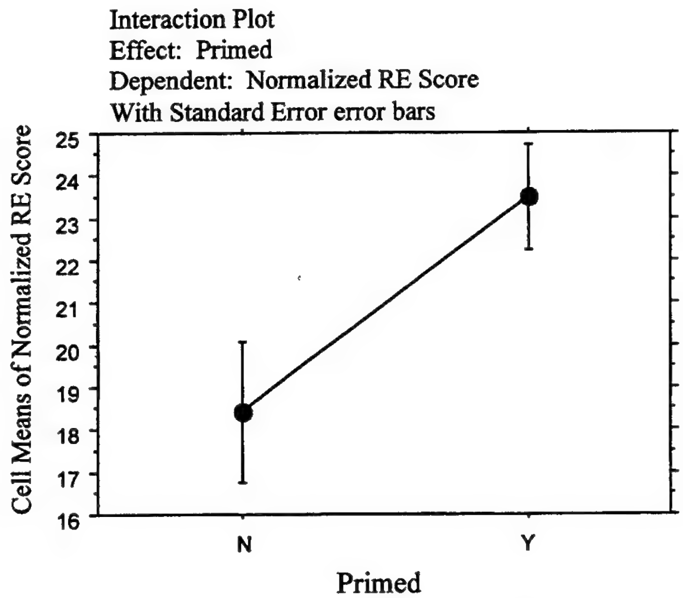

Figure 27: Primed vs Normalized RE Scores

As expected, the results show high significance between primed or unprimed participants and RE test scores, $F(1, 42) = 10.895$, $\underline{P} = 0.0020$. This comparison indicates participants who were unprimed allocated more of their attentional resources to the VE which they believed to be the primary task. Primed participants who had been given the secondary task of attending to the RE divided their attentional resources and scored higher on the RE quiz at the expense of a lower VE score. This supports the results of the comparison between primed and unprimed participants and the VE scores which indicates that VE scores for participants who are primed decreases.

A look at a composite of these comparisons provides a very clear indication of the effects of being primed or unprimed in both the VE and the RE (Figure 28). Viewing these results side by side, it is clearly seen that when the participants are primed, the level of engagement, indicated by the quiz scores, increases in the RE and lowers in the VE. Conversely, when participants are unprimed, the level of engagement in the RE decreases and the level of engagement in the VE increases. This is not to say that the level of engagement is greater in the RE than in the VE in either case. It does appear that there is a limited capacity of attentional resources, however, and that those resources are simply allocated differently when an individual is cognitively directing the allocation of those limited resources

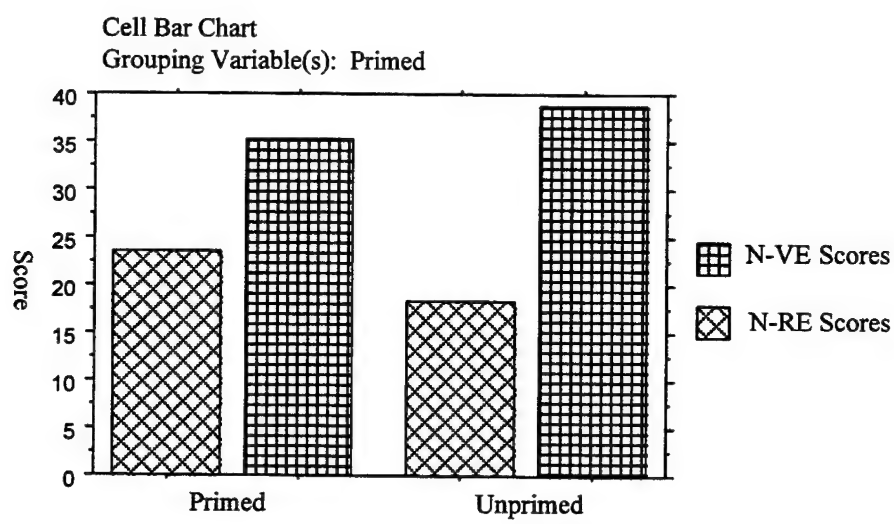

Figure 28: Composite between Primed versus N-VE Scores and N-RE Scores

D. DISCUSSION

To get an overall picture of what was happening during the experiment, it is interesting to look at a combined analysis with all the given variables when the experiment is divided into three separate timed phases. In the graphs to follow, the shifts

and/or division of attention can be seen. The graphs are broken down into primed (Figure 29 and 30) and unprimed (Figure 31 and 32) participants. This is further broken down into displays that did not have sound and displays that did include sound. Each graph contains three series indicating the three visual displays; FS, 3TV and HMD. Focus on VE are indicated above 0 and RE below 0.

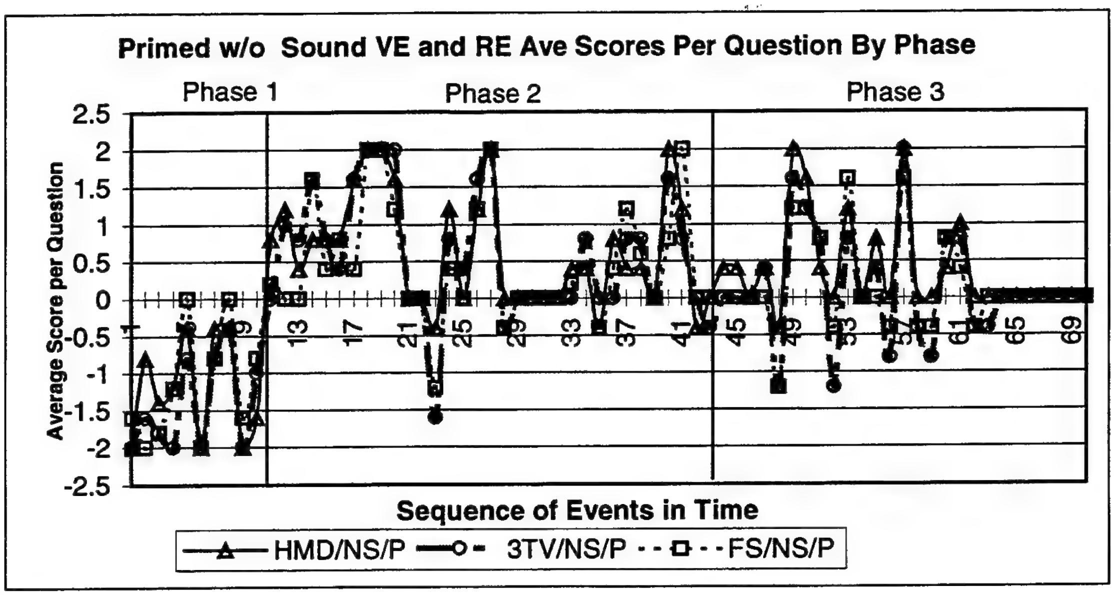

Figure 29: Primed w/o Sound VE and RE Average Scores per Question by Phase

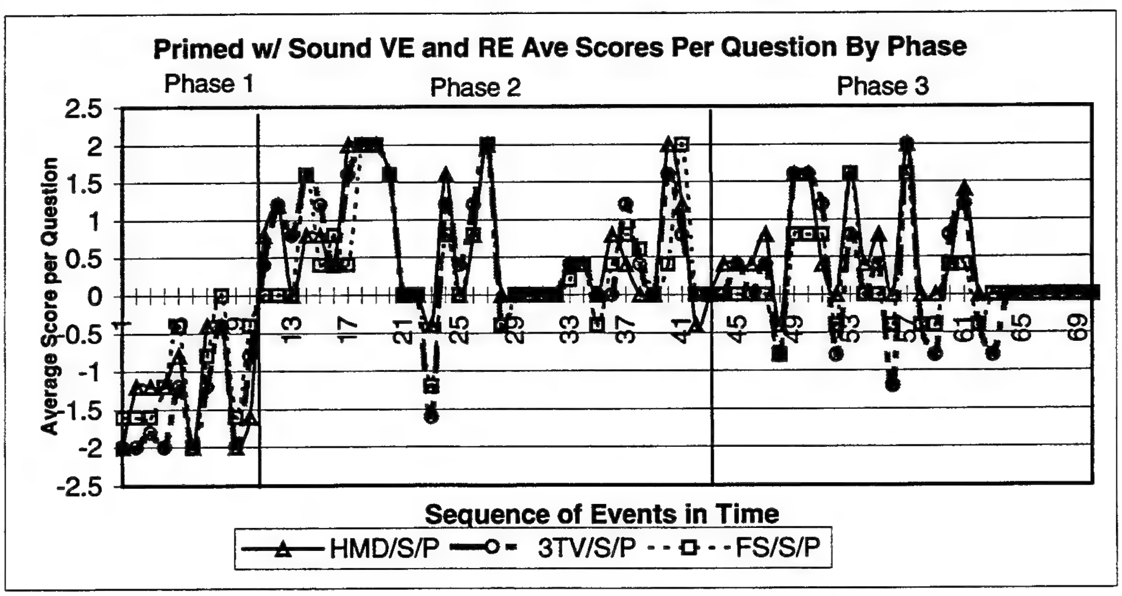

Figure 30: Primed w/ Sound VE and RE Average Scores per Question by Phase

Each graph provides a clear indication of the locus of attention throughout the VE experience. Although the series appear to indicate a distinct drift from one environment to the other, it is important to note that this may not be the case. The points at which the series seem to drift may in fact be a point at which the participants' attention may have been divided between the two environments. An example of such an attentional division is seen in Figures 29 and 30. The spike in the second phase of the RE followed shortly by a spike in the VE correlates to questions pertaining to events that occurred simultaneously in both environments. These events were provided via both aural and visual stimuli and it is highly unlikely that the questions could have been answered correctly without attending to the event.

An interesting point to look at is the apparent effect that priming or not priming the participants had on the level, location and changes in location of engagement. Figures 29, 30, 31 and 32, indicate that primed and unprimed participants were clearly engaged in the RE during the first phase of the experiment. This, of course, was expected due to the fact that participants were only exposed to the RE during the first five minutes with no exposure at that point to the VE. The second phase then begins and there is a clear indication that engagement shifts to the VE. This again was expected because each participant was directed to attend to the VE as the primary task. There appear to be several points in time at which participants shift attention back to the RE or at least divide. The third phase indicates even more occurrences of engagement in the RE for primed participants while still experiencing the VE.

Figures 31 and 32 are the same three phase breakdown of the experiment and participants who were unprimed. Again, the first phase indicates that participants were

engaged in the RE for the same reasons stated before even though they were not told to watch the video. The second phase does show a few instances where engagement shifted to the RE but the third phase clearly indicates no engagement in the RE for the participants who were not primed.

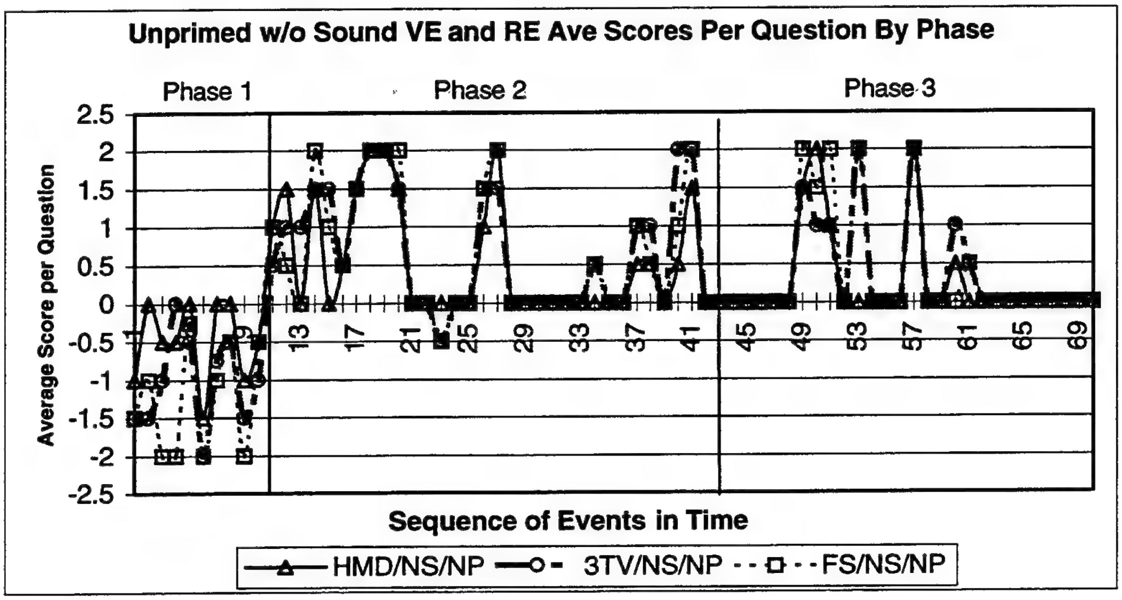

Figure 31: Unprimed w/o Sound VE and RE Average Scores per Question by Phase

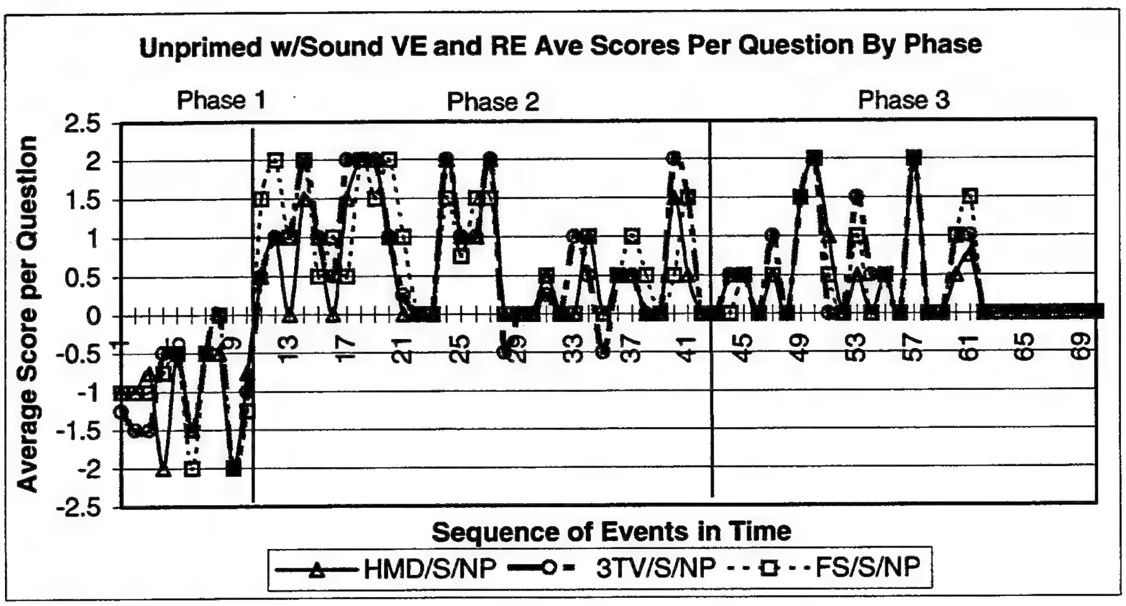

Figure 32: Unprimed w/ Sound VE and RE Average Scores per Question by Phase

The reasons for the differences in shifts of engagement between participants who were primed and those who were not primed vary. It seems that directing participants to attend to both environments simultaneously does have a notable effect. In this study, the first phase is similar for both groups. Even the second phase is similar, but the third phase indicates a remarkable difference in the level of engagement in the RE.

The level of stimulation in the VE is believed to have had a large impact on this. In the second phase for both groups, considering the points in time at which the shift of engagement to the RE occurs in comparison with the events happening in the VE suggests at least one reason why the shift occurs. It appears that the level of interest for the VE is at a very low level for a brief period thus allowing the participants' focus of attention to drift to the RE. Then, events in the VE would draw their attention back.

In the third phase, the participants who were unprimed continued to attempt to focus their attention on the VE which remained the single primary task to be performed. However, the primed participants were attempting to attend to both environments, as they had been directed to attend to both. Therefore, they cognitively controlled shifts of their attentional resources from one environment to the other, particularly in the third phase when events in both the VE and the RE demanded brief updates to follow the story line.

These comparisons suggest that various forms of priming VE users could be beneficial in some future applications of VEs. An example would be a training environment that required the individual to learn to focus on a primary task while still being able to monitor a secondary task of importance such as those involved with medical procedures or nuclear plants. ***Maximizing presence is not always a good thing***.

E. SPATIAL AWARENESS

Observations of participants' knowledge of spatial awareness in the VE were made by asking participants to maneuver as the driver back through the VE via the same route they had been taken as a passenger during the experiment. The observations were interesting but not significant. The data regarding spatial awareness was not gathered or correlated for analysis in this study. However, some observations are worthy of note. The participants that performed well maneuvering back through the environment were those who travel frequently and drive often. Participants indicated that the landmarks were used to help remember the route. Several participants said that they had remembered details of the route in phases. Of particular interest were the comments from participants regarding the absence of the sun that would have provided a sense of direction. This appeared to confuse them and cause some disorientation. Some participants indicated that if they had known the speed of the vehicle, they believed they would have been able to accurately calculate distance in certain directions by the amount of time traveled. However, their was no noted difference due to display type.

F. SUMMARY

The results of the various comparisons throughout this study suggest that within the parameters of the three visual displays, each display will excel under certain conditions. Overall, the HMD appears to provide the greatest level of engagement in the VE while occluding the RE. One reason for this is the restricted FOV outside of that provided by the HMD for the VE model. In addition to the visual occlusion, when sound is used in conjunction with the HMD, further occlusion of the RE occurs. This level of occlusion does not allow the participant to "borrow" attentional resources from either

pool to make up for resources lacking in another pool, whereas, each of the other visual displays would allow such borrowing of attentional resources. This is solid support for the requirement that a display be ***inclusive*** to achieve presence, as Steuer recommends [STEU 95]. This type of display would be useful in situations that required a high level of fidelity in the VE training environment and occlusion of anything outside of that environment. While this will allow engagement to only the VE, and not the RE, the results presented here suggest that the level of detail attended to may not be very high. This could be due to resolution, frame rate, simulator sickness, or the novelty of the experience or the technology.

On the other hand, 3TV provides a high level of engagement in concurrent environments, but does not occlude either environment. It seems that the reason for this is the large FOV. The large FOV allows the participant to comfortably scan the VE without occluding the area outside of the FOV. In this study, this allowed the participants to shift their visual focus between the two stimuli with ease. They were able to attend to both environments without a great deal of physical movement of their head. When no sound was involved, this required a constant shift of their attention back and forth between the two environments. When sound was involved, this was accomplished even easier. Not only were the participants able to shift their visual attention back and forth between the VE and the RE but they only needed to do so when an auditory cue from the VE prompted them. When the cues did not demand attention in the VE to keep up with the story line, they simply used their visual modality to attend to the RE and their auditory modality to attend to the VE. This is supported by videotapes that show primed participants focusing their visual attention on the RE video and using the joystick to draw

the VE into a position on the 3TV that brought the main stimuli of the VE closer to their foveal view. This display would work well in training environments that required focusing on a primary task while still being aware of the surrounding environment or performing a secondary task. These types of tasks would probably involve the awareness of the individual that they needed to attend to the two concurrent tasks. This source of priming has already been discussed as having a positive effect on such desired concurrent engagement. However, even if the dual task requirement is not in effect, results here indicate that the 3TV display may allow a greater level of detail to be extracted from the environment.

FS was less remarkable in relation to the other two visual displays. Because it has the smallest FOV and allows the largest view of the surrounding environment, the result is the lowest level of ***inclusiveness*** as well as the lowest level of ***surrounding***. Although the participants were able to view both the VE and the RE video, the physical head movement required was much greater making the task of maintaining focus on either stimuli difficult and sharing the visual focus concurrently impossible. The small FOV provided by the FS required more use of the joystick in order to view more of the VE landscape. This added to the difficulty of the task. The fact that the FS was unable to provide high levels of engagement in both environments as did the 3TV or engagement in one environment while occluding the other as does the HMD makes its use less beneficial for most large scale training VEs. FS would, however, be ideal for other uses. The uses might include small-scale training of more simplistic tasks that do not involve great attention to detail or necessitate the transfer of large amounts of information. In some situations, FS would be the most cost effective for the particular training demands.

The use of sound increased the level of engagement across all conditions. Participants' responses on the PQ (See Appendix E-4) indicated their senses were completely engaged when using displays with sound (Appendix E-4, Question 6), $F(1,42) = 13.225$, $\underline{P} = 0.0007$, and believed that the visual aspects of the environment involved them completely (Appendix E-4, Question 6), $F(1,42) = 7.908$, $\underline{P} = 0.0074$. Of particular interest, participants reported a compelling sense of objects moving through space (Appendix E-4, Question 12), $F(1,42) = 14.346$. $\underline{P} = 0.0005$, and of moving around inside the virtual environment (Appendix E-4, Question 19), $F(1,42) = 8.448$, $\underline{P} = 0.0058$. The ability to examine objects closely (Appendix E-4, Question 20), $F(1,42) = 9.997$, $\underline{P} = 0.0029$, and from multiple view points (Appendix E-4, Question 21), $F(1,42) = 5.237$, $\underline{P} = 0.0272$, was significantly increased for participants using displays with sound. Participants using displays with sound also indicated that they felt they were involved in the VE experience (Appendix E-4, Question 24), $F(1,42) = 7.059$, $\underline{P} = 0.0111$ and that they lost track of time during the experience frequently (Appendix E-4, Question 32), $F(1,42) = 4.812$. $\underline{P} = 0.0338$. This further supports research that indicates the importance of sound in VEs [GILK 95], [HEND 96] and reinforces the requirements for displays to be as extensive as possible [STEU 95]. Sound is indicated as a vital element for increasing engagement in VEs.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

This study has investigated the effects of a variety of factors on engagement in VEs in an attempt to develop a metric for presence. The purpose of the experiment was to discover which of three visual displays combined with the presence or absence of sound and with or without the direction to attend to a secondary task would provide the greatest level of presence or engagement in one experience as a function of disengagement from a concurrent experience.

The experimental design was based on the idea that using the dual task paradigm of attention theory would provide a way of quantifiably measuring the degree of engagement in a primary task by seeking objective answers to questions that deal specifically with that task and with a secondary task that competes for attentional resources of the participant. This obviously is not a single, final solution to developing a quantifiable measure for presence but there is reason to be optimistic based on the correlation found between this method and the PQ scores. Certainly, there are elements of presence not addressed by attention alone, but attention seems to be an important component of presence that is reasonably measurable.

In summary, these are the significant findings of this study.

- HMD occluded the RE preventing participants from dividing their attentional resources between the RE and the VE.
- 3TV enabled participants to attend to the two environments concurrently and extract more detail from both.
- Including sound in the displays increased the amount of detail the participants were able to extract from both the VE and the RE.

- The addition of sound to all three displays increased the level of engagement in the VE significantly as was expected.
- Based upon the correlation between the PQ scores and the normalized VE scores, it appears that this metric is valid.
- Results strongly indicate that primed participants divide their attentional resources between the environments, lowering the level of engagement in the VE and increasing the level of engagement in the RE. Conversely, unprimed participants' levels of engagement lowered in the RE and increased in the VE. Note this does not mean that engagement was greater in the RE in either case but that there was a shift in the allocation of limited attentional resources.
- The increased levels of engagement in both environments in response to directives given to participants to attend to a secondary task also were expected.

These results provide useful information which will help guide future research in the development of a standardized metric of presence.

After analyzing the results, it becomes easier to envision other aspects of the experiment that might have been helpful. It also helps point out aspects of this experiment that might have actually been a hindrance.

B. RECOMMENDATIONS

In retrospect, this experiment should have been created so that both environments could have been analyzed in small slices of time. The quiz questions would have been carefully designed to provide exact information indicating the locus of attention at precise moments. The questions would have corresponded in time between the VE and the RE precisely so the participant could answer one or the other, or both indicating divided or focussed attention.

The number of audio and visual questions would have been the same for each environment. The questions would have been designed for the environments so they could be answered by the visual modality or the aural modality but not both.

Tests would have been given to determine each participant's dominant representation system. This would be another element to include in the data that might help determine the reason why some measures are so variant.

A sterile lab environment would have been helpful in ensuring a totally consistent experience for each participant. The timing of the events would have coincided perfectly for each participant.

Measurements of movement for the joystick and head tracking would have been recorded so that visual shifts between environments could be correlated with events happening in the environments.

Including these elements could prove valuable in future research.

C. FUTURE WORK

This thesis has reviewed relevant research, theories, and speculations concerning the intriguing and important phenomenon we call presence. Furthermore, it demonstrates that research on presence still remains in its infancy as suggested by Slater [SLAT 96]. Relatively little is understood about the characteristics that make up presence and how it can create the sensation of "being there". In addition, relatively little is understood about the effects of presence once it is evoked. Is there any correlation between presence and task performance? We still do not know. Given the theoretical importance of the concept of presence, what future research is needed in order to reap the benefits believed to be associated with a sense of presence in VEs?

This study may serve as a foundation for a future attempt at a similar study utilizing the recommendations mentioned above. It would be interesting to conduct this study again integrating the above recommendations with detailed physiological measurements and observations such as heart rate, pulse, biofeedback, muscle conductance, blood pressure, respiratory rate, and pupil dilation. The use of a VE body representation could enhance the experience and may prove helpful in observing pronounced behavioral responses. Many aspects of the two concurrent environments should be rethought and a model built to specifically enlist the use of time analysis. The use of a transitory VE would be interesting, perhaps, creating the concurrent experiences both within the VE and the RE but still in a manner of competition for attentional resources.

Systematic research needs to be continued seeking to discover all avenues that lead to the phenomenon of presence in VEs. This research has explored one of those avenues using attention theory as a basis. This avenue should continue to be investigated as well as the many other avenues that relate to presence.

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APPENDIX A. RAW DATA

SUB	AGE	SEX	PRI	SND	TREAT	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-11	V-12	V-13	V-14	V-15
1	32	M	N	Y	HMD	2	2	2	0	0	0	2	2	0	2	0	2	2	2	0
2	30	M	N	Y	HMD	2	2	2	0	0	2	2	2	0	2	2	2	2	2	2
3	29	F	N	Y	HMD	2	0	2	0	0	0	2	0	0	0	2	2	0	2	0
4	35	F	N	Y	HMD	2	0	2	0	2	0	2	2	0	2	2	2	0	2	0
5	46	F	N	Y	3TV	2	2	2	0	0	0	2	2	0	0	2	2	0	2	2
6	30	M	N	Y	3TV	2	2	2	0	2	2	2	2	2	2	2	2	0	2	2
7	54	M	N	Y	3TV	2	0	2	0	0	0	2	2	0	2	2	2	0	2	2
8	64	M	N	Y	3TV	2	0	2	0	0	0	2	2	0	2	2	2	0	2	0
9	21	F	N	Y	FS	2	2	2	2	2	0	2	0	0	0	0	2	0	2	2
10	28	F	N	Y	FS	2	2	0	0	2	2	2	0	2	2	0	2	0	2	2
11	40	F	N	Y	FS	2	0	2	0	0	0	0	2	0	2	0	2	0	2	2
12	15	M	N	Y	FS	2	2	2	0	2	2	2	0	2	2	2	2	2	2	0
13	35	M	N	N	HMD	2	0	2	2	2	0	2	2	0	2	2	2	0	2	2
14	28	M	N	N	HMD	2	0	2	0	2	0	2	0	0	2	2	2	0	2	0
15	37	M	N	N	HMD	2	2	2	0	0	0	2	0	0	0	0	2	2	2	2
16	39	M	N	N	HMD	2	2	2	0	0	2	2	0	2	2	2	2	2	2	2
17	31	M	N	N	3TV	2	0	2	0	0	0	2	2	2	0	0	0	2	2	2
18	20	F	N	N	3TV	2	2	2	2	2	2	0	2	0	2	2	2	0	2	2
19	36	M	N	N	3TV	2	2	2	0	0	2	2	2	0	2	2	0	0	2	2
20	37	M	N	N	3TV	2	2	2	2	0	0	2	2	0	2	2	2	2	2	2
21	33	M	N	N	FS	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2
22	32	F	N	N	FS	2	2	2	2	2	2	2	0	0	2	0	2	2	2	2
23	53	F	N	N	FS	2	0	2	0	0	0	2	2	0	2	2	2	2	2	2
24	29	M	N	N	FS	2	2	2	0	0	0	2	0	0	2	2	0	2	2	2
25	41	M	Y	N	HMD	2	0	2	2	0	0	2	0	0	2	2	2	0	2	0
26	61	M	Y	N	HMD	2	0	2	0	0	0	2	0	2	0	0	0	0	0	2
27	50	M	Y	N	HMD	2	2	2	0	2	0	2	0	0	2	2	2	2	2	2
28	30	M	Y	N	HMD	2	2	2	2	2	0	2	2	2	2	0	2	0	2	2
29	30	F	Y	N	HMD	2	2	2	0	0	0	2	2	0	2	2	2	2	2	2
31	33	M	Y	Y	HMD	2	2	2	0	0	2	2	2	0	2	2	2	0	2	0
32	13	M	Y	Y	HMD	2	0	2	0	2	0	2	2	2	2	2	0	0	2	2
33	49	F	Y	Y	HMD	2	0	2	0	2	0	2	2	0	0	2	2	0	2	2
34	23	M	Y	Y	HMD	2	0	0	0	2	2	2	2	2	2	2	2	0	2	0
35	38	M	Y	N	3TV	2	2	2	2	0	0	2	0	0	2	0	2	2	2	0
36	31	M	Y	N	3TV	2	0	0	0	0	2	2	2	0	2	0	0	0	2	2
37	39	M	Y	N	3TV	2	2	2	2	0	0	2	2	0	2	2	0	0	2	0
38	37	M	Y	N	3TV	2	2	2	0	0	2	2	2	2	2	2	2	0	2	2
39	51	M	Y	N	3TV	2	2	2	0	0	2	2	2	0	0	2	0	2	2	2
40	57	M	Y	Y	3TV	2	2	2	2	0	0	2	2	0	2	2	2	2	2	0
41	51	M	Y	Y	3TV	2	0	2	0	0	0	2	0	0	2	0	2	0	2	0
42	43	M	Y	Y	3TV	2	0	2	0	2	2	2	2	0	2	2	2	2	2	0

43	40	F	Y	Y	3TV	2	0	2	0	2	0	2	2	2	2	2	0	2	0	2
44	30	F	Y	Y	3TV	2	0	2	0	0	2	2	2	2	2	2	2	2	2	2
45	15	M	Y	N	FS	2	0	2	0	2	0	2	0	2	2	0	2	2	2	0
46	16	M	Y	N	FS	2	2	2	0	1	2	2	2	2	2	0	2	0	2	2
47	32	M	Y	N	FS	2	2	2	0	0	2	2	0	2	0	0	0	2	2	2
48	48	M	Y	N	FS	2	0	2	2	0	0	2	0	0	2	0	2	0	2	2
49	41	M	Y	N	FS	2	2	2	1	0	0	2	2	0	0	2	0	2	0	2
50	34	M	Y	Y	FS	2	0	2	0	0	2	2	0	0	2	0	2	0	2	2
51	63	F	Y	Y	FS	2	0	2	0	0	0	2	0	2	0	0	0	0	2	2
52	47	M	Y	Y	FS	2	0	2	0	2	0	2	2	2	0	2	0	0	2	2
53	52	M	Y	Y	FS	2	2	2	2	2	0	2	2	0	2	2	2	2	2	2
54	33	F	Y	Y	FS	2	2	2	0	2	0	2	2	2	2	2	2	0	2	2
55	29	M	BLV	NA	BV	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
56	33	M	BLV	NA	BV	2	2	2	0	1	0	2	2	1	2	2	2	2	2	2
57	40	M	BLV	NA	BV	2	0	2	0	2	0	2	2	2	1	2	2	1	2	2
58	35	M	BLV	NA	BV	2	0	2	0	2	2	0	2	2	2	2	0	2	2	2
59	36	M	BLV	NA	BV	2	0	2	2	2	2	2	2	0	2	2	2	0	2	2
60	33	F	BLV	NA	BV	2	2	2	2	2	0	2	2	0	0	2	2	0	2	2
61	39	M	BLV	NA	BV	2	0	2	0	0	0	2	2	2	2	2	0	0	2	2
62	35	M	BLV	NA	BV	2	0	2	0	2	0	2	2	0	2	2	2	0	2	0
63	38	M	BLV	NA	BV	2	0	2	0	2	0	2	2	0	0	0	2	0	2	0
64	27	M	BLV	NA	BV	2	2	2	0	2	0	2	2	0	2	2	2	0	2	0
65	15	M	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	16	M	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	21	M	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	14	M	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	44	F	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	38	M	BLR	NA	BR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SUB	V-16	V-17	V-18	V-19	V-20	V-21	V-22	V-23	V-24	V-25	V-26	V-27	V-28	V-29	V-30	V-31	V-32	V-33	V-34	V-35	V-36	V-37
1	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
2	2	2	2	0	1	2	0	2	2	0	0	0	0	2	0	2	2	2	0	0	0	0
3	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
4	0	0	2	0	0	2	2	0	0	0	0	0	0	2	0	2	0	0	2	0	0	0
5	0	0	0	1	0	2	0	2	0	0	0	0	0	2	0	0	1	0	2	0	0	2
6	2	2	2	0	2	2	0	0	2	2	0	0	0	0	2	0	0	0	2	0	0	2
7	0	2	2	0	2	2	0	0	0	2	0	0	0	0	0	2	0	0	2	0	0	0
8	2	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	2	2	0	0	0
9	0	2	2	2	2	2	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
10	0	2	2	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
11	2	2	2	0	2	2	0	0	0	0	0	0	0	2	0	2	2	2	2	0	0	0
12	2	2	2	2	0	0	0	2	2	2	0	0	0	1	0	0	0	0	2	0	0	0
13	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
14	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
16	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
17	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
18	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
19	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
20	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0
21	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
22	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
23	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
24	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
25	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
29	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
31	0	2	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0	2	0	0	0	0
32	0	2	2	0	2	2	0	0	2	0	0	0	0	0	2	0	0	2	0	0	0	2
33	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2
34	0	0	2	0	2	2	0	2	0	0	0	0	0	2	0	0	0	0	2	0	0	0
35	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
36	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
37	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
38	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	2	0	0	0
39	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	2	2	0	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
41	0	2	2	0	2	2	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0
42	0	0	2	0	2	2	0	2	0	0	0	0	0	0	2	0	0	0	2	0	0	0
43	0	0	0	2	0	0	2	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0
44	0	2	0	0	2	2	2	2	0	2	0	0	0	0	2	0	0	1	2	0	0	2
45	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0

46	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
47	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
48	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
49	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
50	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	2	2	0	0	0
51	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
52	0	2	2	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
53	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0
54	2	2	2	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
55	2	2	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
56	0	2	1	0	2	2	1	0	0	2	0	0	0	0	0	2	0	0	2	0	0	0
57	2	2	2	0	2	2	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0
58	2	2	2	2	2	2	2	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0
59	0	0	0	1	0	2	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0
60	2	2	0	0	1	2	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
61	0	2	0	2	0	2	0	2	0	0	0	0	0	0	2	2	0	2	2	0	0	2
62	2	2	2	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
63	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0
64	0	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SUB	V-38	V-39	V-40	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10	R-11	R-12	R-13	R-14	R-15	R-16	R-17	R-18	R-19
1	2	0	2	1	2	0	2	2	0	0	0	0	2	2	0	2	0	0	0	0	0	0
2	0	0	2	2	1	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
3	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0	0
4	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	2	0	0	0	0	0	0
5	0	0	0	2	2	2	2	2	2	0	2	0	0	2	0	2	2	0	0	0	0	0
6	2	0	2	2	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
7	2	0	2	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0
8	2	2	0	2	2	0	1	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0
9	2	0	0	2	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
11	0	0	0	0	2	2	0	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0
12	2	0	2	2	2	0	2	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	2	2	0	2	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0
15	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17	2	0	2	0	0	0	0	2	2	0	0	0	2	2	0	0	0	0	0	0	0	0
18	2	0	0	2	2	0	2	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0
19	2	0	2	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
20	2	0	2	2	2	2	2	0	2	2	0	0	0	2	0	0	0	0	0	0	0	0
21	2	0	2	2	2	1	2	2	2	0	0	0	0	0	0	2	0	0	0	0	0	0
22	2	0	2	2	0	0	2	2	2	2	0	0	0	2	0	2	0	0	0	0	0	0
23	2	0	0	2	0	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
24	2	0	0	2	0	0	0	2	2	0	0	0	2	0	0	2	0	0	0	0	0	0
25	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	2	0	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
27	2	0	0	2	2	2	2	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0
28	0	0	2	2	2	0	2	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0
29	2	0	0	2	2	2	2	2	2	2	0	0	2	2	0	2	0	0	0	2	0	0
31	0	0	0	1	0	0	2	2	2	0	0	0	0	2	0	0	0	0	0	0	0	0
32	2	0	2	0	2	0	2	2	2	0	0	0	0	0	0	0	0	2	0	0	0	0
33	2	2	2	1	2	2	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
34	0	0	2	1	0	0	2	2	2	0	0	0	0	1	0	0	0	0	0	0	0	0
35	0	0	0	2	0	2	2	2	2	2	0	0	0	2	0	2	0	0	0	0	0	0
36	2	0	0	2	0	0	2	2	2	2	0	0	2	2	0	2	0	0	2	2	0	2
37	0	0	0	2	2	0	2	2	2	2	0	0	0	0	0	2	0	0	2	2	2	0
38	2	0	2	2	0	2	2	2	2	2	0	0	0	2	0	2	0	0	0	2	2	2
39	0	0	0	1	1	0	2	2	2	2	2	2	0	2	0	2	0	0	0	2	2	2
40	2	0	0	2	2	2	2	2	2	2	0	0	2	2	0	2	0	0	0	0	0	0
41	0	0	2	2	0	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
42	0	0	2	2	1	2	2	2	2	2	0	0	0	2	0	2	0	0	0	0	0	2
43	0	0	0	2	0	0	2	2	2	2	2	0	0	0	0	2	0	0	0	0	2	0
44	2	0	2	2	2	0	2	2	2	0	0	0	0	2	0	0	0	0	0	2	0	0
45	0	0	2	1	0	0	2	2	2	2	2	0	0	2	0	2	0	0	0	2	2	0

46	2	0	2	1	2	0	2	2	2	0	0	0	0	2	0	2	0	0	0	2	0	0
47	2	0	0	2	0	0	2	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0
48	2	0	0	2	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	2	0	0
49	0	0	0	2	0	0	2	2	2	2	0	0	0	2	0	2	2	0	0	2	2	2
50	2	0	0	2	2	0	2	2	2	2	2	2	0	2	0	0	0	0	0	0	0	0
51	2	0	2	0	0	2	2	2	2	0	0	0	0	0	0	2	0	0	0	0	0	0
52	0	0	2	2	0	2	2	2	2	2	0	0	2	2	0	2	0	2	0	2	0	0
53	2	0	0	2	2	0	2	2	2	2	0	0	0	0	0	0	0	0	0	2	0	0
54	2	0	2	2	2	0	2	2	2	2	2	0	0	2	0	2	0	0	0	0	2	2
55	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	2	0	0	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2
66	0	0	0	2	1	2	2	2	2	2	2	2	0	2	1	2	2	0	2	2	2	2
67	0	0	0	2	2	1	2	2	2	0	2	2	0	2	0	2	0	1	2	2	2	2
68	0	0	0	2	2	2	2	2	2	2	2	2	2	2	1	2	0	1	2	2	2	2
69	0	0	0	2	2	2	2	2	2	2	2	2	0	0	0	2	0	2	2	2	2	2
70	0	0	0	2	2	2	2	2	2	2	2	0	1	2	0	2	2	1	2	2	2	2

SUB	R-20	R-21	R-22	R-23	R-24	R-25	R-26	R-27	R-28	R-29	R-30	N-VV	N-VA	N-RV	N-RA	N-VE-S	N-RE-S	VE-RE
1	0	0	0	0	0	0	0	0	0	0	0	56.0	25.0	19.6	39.3	40.5	22.3	18.2
2	0	0	0	0	0	0	0	0	0	2	0	70.0	42.5	26.8	46.4	56.3	34.6	21.6
3	0	0	0	0	0	0	0	0	0	0	0	32.0	10.0	10.7	14.3	21.0	10.4	10.6
4	0	0	0	0	0	0	0	0	0	0	0	48.0	25.0	14.3	14.3	36.5	19.6	16.9
5	0	0	0	0	0	0	0	0	0	2	0	44.0	30.0	35.7	57.1	37.0	32.9	4.1
6	0	0	0	0	0	0	0	0	0	0	0	88.0	35.0	14.3	28.6	61.5	24.6	36.9
7	0	0	0	0	0	0	0	0	0	0	0	68.0	25.0	7.1	14.3	46.5	16.1	30.4
8	0	0	0	0	0	0	0	0	0	0	0	44.0	40.0	19.6	39.3	42.0	29.8	12.2
9	0	0	0	0	0	0	0	0	0	0	0	60.0	30.0	10.7	21.4	45.0	20.4	24.6
10	0	0	0	0	0	0	0	0	0	2	0	64.0	20.0	23.2	39.3	42.0	21.6	20.4
11	0	0	0	0	0	0	0	0	0	0	0	52.0	35.0	16.1	21.4	43.5	25.5	18.0
12	0	0	0	0	0	0	0	0	0	0	0	76.0	27.5	21.4	42.9	51.8	24.5	27.3
13	0	0	0	0	0	0	0	0	0	0	0	56.0	5.0	0.0	0.0	30.5	2.5	28.0
14	0	0	0	0	0	0	0	0	0	0	0	36.0	5.0	17.9	28.6	20.5	11.4	9.1
15	0	0	0	0	0	0	0	0	0	0	0	44.0	5.0	10.7	21.4	24.5	7.9	16.6
16	0	0	0	0	0	0	0	0	0	0	0	60.0	5.0	7.1	14.3	32.5	6.1	26.4
17	0	0	0	0	0	0	0	0	0	0	0	56.0	10.0	10.7	28.6	33.0	10.4	22.6
18	0	0	0	0	0	0	0	0	0	0	0	64.0	15.0	21.4	42.9	39.5	18.2	21.3
19	0	0	0	0	0	0	0	0	0	2	0	60.0	10.0	14.3	28.6	35.0	12.1	22.9
20	0	0	0	0	0	0	0	0	0	1	0	72.0	15.0	26.8	46.4	43.5	20.9	22.6
21	0	0	0	0	0	0	0	0	0	2	0	76.0	10.0	26.8	42.9	43.0	18.4	24.6
22	0	0	0	0	0	0	0	0	0	0	0	64.0	10.0	25.0	42.9	37.0	17.5	19.5
23	0	0	0	0	0	0	0	0	0	0	0	60.0	20.0	21.4	35.7	40.0	20.7	19.3
24	0	0	0	0	0	0	0	0	0	2	0	48.0	10.0	17.9	35.7	29.0	13.9	15.1
25	0	0	0	0	0	0	0	0	0	0	0	44.0	5.0	14.3	21.4	24.5	9.6	14.9
26	0	0	0	0	0	0	0	0	0	2	0	20.0	0.0	25.0	42.9	10.0	12.5	2.5
27	0	0	0	0	0	0	0	0	0	0	0	52.0	10.0	25.0	42.9	31.0	17.5	13.5
28	0	0	0	0	0	0	0	0	0	0	0	64.0	5.0	21.4	42.9	34.5	13.2	21.3
29	0	0	0	0	0	0	0	0	0	2	0	68.0	15.0	39.3	71.4	41.5	27.1	14.4
31	0	0	0	0	0	0	0	0	0	0	0	48.0	35.0	16.1	32.1	41.5	25.5	16.0
32	0	0	0	0	0	0	0	0	0	0	0	64.0	40.0	17.9	28.6	52.0	28.9	23.1
33	0	0	0	0	0	0	0	0	0	0	0	60.0	35.0	26.8	39.3	47.5	30.9	16.6
34	0	0	0	0	0	0	0	0	0	0	0	56.0	25.0	14.3	28.6	40.5	19.6	20.9
35	2	0	0	0	0	0	0	0	0	2	0	44.0	5.0	35.7	50.0	24.5	20.4	4.1
36	1	0	0	0	0	0	0	0	0	2	0	40.0	10.0	41.1	71.4	25.0	25.5	0.5
37	0	0	0	0	0	0	0	0	0	0	0	50.0	10.0	35.7	57.1	30.0	22.9	7.1
38	2	2	2	0	0	0	0	0	0	2	0	76.0	15.0	53.6	57.1	45.5	34.3	11.2
39	0	2	0	0	0	0	0	0	0	2	0	48.0	5.0	50.0	57.1	26.5	27.5	1.0
40	0	0	0	0	0	0	0	0	0	0	0	72.0	25.0	32.1	57.1	48.5	28.6	19.9
41	0	0	0	0	0	0	0	0	0	0	0	44.0	25.0	21.4	35.7	34.5	23.2	11.3
42	0	0	2	0	0	0	0	0	0	2	0	60.0	25.0	41.1	53.6	42.5	33.0	9.5
43	2	2	0	0	0	0	0	0	0	2	0	44.0	15.0	39.3	42.9	29.5	27.1	2.4
44	0	0	0	0	2	0	0	0	0	2	0	76.0	42.5	32.1	57.1	59.3	37.3	21.9
45	0	0	0	0	0	0	0	0	0	0	0	52.0	5.0	33.9	46.4	28.5	19.5	9.0

46	0	0	0	0	0	0	0	0	0	0	0	62.0	10.0	26.8	46.4	36.0	18.4	17.6
47	0	0	0	0	0	0	0	0	0	0	0	52.0	15.0	21.4	35.7	33.5	18.2	15.3
48	0	0	0	0	0	0	0	0	0	0	0	44.0	10.0	17.9	35.7	27.0	13.9	13.1
49	2	2	0	0	0	0	0	0	0	2	0	42.0	5.0	46.4	64.3	23.5	25.7	2.2
50	0	0	0	0	0	0	0	0	0	2	0	44.0	22.5	35.7	57.1	33.3	29.1	4.1
51	0	0	0	0	0	0	0	0	0	0	0	40.0	15.0	17.9	21.4	27.5	16.4	11.1
52	0	0	0	0	0	0	0	0	0	0	0	60.0	15.0	35.7	57.1	37.5	25.4	12.1
53	0	0	0	0	0	0	0	0	0	2	0	72.0	25.0	28.6	57.1	48.5	26.8	21.7
54	0	0	0	0	0	0	0	0	0	0	0	76.0	15.0	39.3	50.0	45.5	27.1	18.4
55	0	0	0	0	0	0	0	0	0	0	0	84.0	30.0	0.0	0.0	57.0	15.0	42.0
56	0	0	0	0	0	0	0	0	0	0	0	72.0	25.0	0.0	0.0	48.5	12.5	36.0
57	0	0	0	0	0	0	0	0	0	0	0	74.0	22.5	0.0	0.0	48.3	11.3	37.0
58	0	0	0	0	0	0	0	0	0	0	0	68.0	37.5	0.0	0.0	52.8	18.8	34.0
59	0	0	0	0	0	0	0	0	0	0	0	52.0	30.0	0.0	0.0	41.0	15.0	26.0
60	0	0	0	0	0	0	0	0	0	0	0	62.0	25.0	0.0	0.0	43.5	12.5	31.0
61	0	0	0	0	0	0	0	0	0	0	0	56.0	50.0	0.0	0.0	53.0	25.0	28.0
62	0	0	0	0	0	0	0	0	0	0	0	72.0	25.0	0.0	0.0	48.5	12.5	36.0
63	0	0	0	0	0	0	0	0	0	0	0	40.0	17.5	0.0	0.0	28.8	8.8	20.0
64	0	0	0	0	0	0	0	0	0	0	0	52.0	15.0	0.0	0.0	33.5	7.5	26.0
65	1	1	0	2	0	0	0	0	0	2	0	0.0	0.0	64.3	71.4	0.0	32.1	32.1
66	2	2	2	0	0	0	0	0	0	2	0	0.0	0.0	67.9	75.0	0.0	33.9	33.9
67	2	2	2	0	0	0	0	0	0	0	0	0.0	0.0	60.7	57.1	0.0	30.4	30.4
68	2	2	2	0	0	0	0	0	0	0	0	0.0	0.0	67.9	71.4	0.0	33.9	33.9
69	1	1	2	0	0	0	0	0	0	0	0	0.0	0.0	60.7	57.1	0.0	30.4	30.4
70	2	2	2	0	0	0	0	0	0	2	0	0.0	0.0	66.1	82.1	0.0	33.0	33.0

SUB	Q1-1	Q1-2	Q1-3	Q1-4	Q1-5	Q1-6	Q1-7	Q1-8	Q1-9	Q1-10	Q1-11	Q1-12	Q1-13	Q1-14	Q1-15	Q1-16	Q1-17	Q1-18	Q1-19	Q1-20	Q1-21	Q1-22
1	6	5	5	7	6	7	7	7	5	7	7	0	7	7	4	7	6	7	5	7	6	4
2	6	4	6	5	6	3	6	3	5	5	5	0	6	5	6	3	2	6	4	6	2	4
3	4	6	6	6	3	6	6	5	6	5	5	0	5	6	6	6	7	1	5	6	2	4
4	6	6	5	5	4	3	5	3	3	2	7	0	5	5	3	3	2	2	6	5	3	5
5	4	4	3	6	5	4	6	2	3	2	6	0	3	4	5	2	1	4	6	4	2	4
6	5	6	5	6	5	5	5	5	5	5	4	0	5	6	1	2	3	6	6	5	3	6
7	5	3	5	6	5	5	5	3	4	3	5	0	5	5	5	4	4	6	3	7	1	3
8	6	7	4	4	5	4	5	3	5	2	6	0	5	6	5	4	1	2	5	6	2	5
9	6	5	5	6	5	4	6	5	4	3	4	0	6	7	2	2	4	1	6	7	2	4
10	6	3	6	6	5	5	6	5	6	4	5	0	6	6	1	2	7	7	3	7	2	3
11	5	7	6	7	7	6	6	5	5	2	7	0	4	6	6	6	6	5	6	7	1	3
12	1	6	2	3	2	2	5	2	2	7	4	0	5	4	1	4	1	5	1	7	7	1
13	6	4	6	5	6	6	6	6	6	3	5	0	6	4	3	4	5	7	2	7	4	2
14	6	4	2	5	4	2	4	2	3	6	5	0	5	5	4	2	2	2	5	5	4	5
15	6	4	5	5	4	1	5	1	4	2	4	0	4	4	4	1	3	3	5	6	2	4
16	6	6	5	6	5	2	6	2	5	1	6	0	6	6	5	2	4	5	6	6	2	5
17	5	3	4	6	5	2	6	5	4	5	4	0	5	4	2	3	2	3	3	6	4	2
18	5	6	6	5	7	7	7	5	7	5	6	0	5	6	1	1	7	1	5	7	5	3
19	5	7	6	6	5	6	7	3	4	4	5	0	4	5	6	2	4	3	6	7	2	6
20	6	6	4	5	2	3	6	4	4	1	6	0	4	3	4	1	5	2	2	6	4	3
21	6	3	3	3	3	3	3	3	4	2	6	0	5	5	4	2	2	4	5	6	1	4
22	6	6	6	7	7	7	6	7	5	5	6	0	7	7	6	6	6	7	5	6	2	6
23	5	7	4	7	6	2	7	5	6	1	4	0	5	6	2	3	5	2	6	7	1	5
24	6	5	2	6	4	1	6	2	3	1	4	0	6	6	5	1	2	6	6	5	5	6
25	6	7	3	7	4	2	6	2	5	4	5	0	5	3	2	2	3	4	6	6	3	6
26	7	1	6	7	7	5	7	5	7	3	5	0	6	3	1	5	5	5	2	7	1	3
27	6	7	5	7	6	5	7	6	6	5	7	0	5	6	6	4	3	5	6	7	4	4
28	6	5	2	6	5	5	5	5	4	6	6	0	5	7	5	6	5	5	5	5	2	5
29	6	5	3	7	6	6	6	5	5	1	5	0	5	5	1	4	3	4	4	5	1	4
31	5	4	4	5	4	5	5	4	5	4	5	0	6	4	5	4	3	5	4	6	2	4
32	6	7	7	7	5	6	6	6	7	7	6	0	7	4	3	6	5	4	4	6	7	3
33	6	6	5	6	6	5	5	6	6	4	6	0	5	4	5	4	3	2	4	5	2	2
34	5	5	4	5	5	5	6	5	5	6	5	0	5	6	4	6	6	5	6	7	6	5
35	5	2	4	4	5	5	6	5	6	3	5	0	5	4	3	4	4	6	3	6	1	3
36	5	4	6	6	6	6	6	6	6	5	6	0	5	6	4	5	4	5	3	6	4	5
37	6	7	5	6	5	7	7	6	3	6	4	0	6	6	5	7	6	6	6	7	1	6
38	5	5	5	6	5	2	5	2	5	1	4	0	6	5	3	1	5	3	4	6	2	4
39	5	6	3	6	5	6	4	4	5	4	4	0	5	5	5	5	5	4	5	4	3	3
40	5	3	6	6	4	6	6	4	5	1	5	0	5	5	5	4	3	4	4	5	1	3
41	6	7	6	6	6	1	6	1	5	1	7	0	7	6	1	1	1	5	7	6	1	7
42	7	7	3	7	4	2	7	1	4	1	5	0	7	3	1	2	3	4	2	5	1	6
43	5	5	6	7	7	5	7	5	6	5	6	0	5	5	5	5	5	4	3	6	4	5
44	5	5	3	5	6	6	7	5	3	1	6	0	6	6	2	2	2	5	5	6	1	4
45	6	5	1	4	2	5	5	4	2	7	6	0	6	5	1	2	2	7	4	7	7	3

46	5	6	4	6	2	4	7	3	2	1	6	0	5	6	5	4	2	6	6	6	4	5
47	2	7	3	6	3	2	7	2	4	2	5	0	6	6	7	2	2	7	6	7	2	5
48	6	5	6	3	6	7	4	5	5	2	5	0	2	6	6	4	2	5	4	6	2	3
49	7	6	5	7	5	7	6	5	5	1	6	0	6	6	5	2	2	6	6	6	1	5
50	6	4	6	7	6	6	6	6	4	3	5	0	5	6	3	2	2	4	3	7	2	3
51	5	6	6	7	6	5	5	5	5	2	4	0	5	5	5	2	6	3	5	5	1	3
52	7	7	4	7	4	1	7	1	7	1	4	0	7	7	7	1	7	6	7	7	1	7
53	6	3	4	5	5	6	6	5	5	5	5	0	5	5	5	4	3	5	6	6	3	3
54	5	2	5	3	5	2	5	2	5	1	7	0	2	3	4	3	6	5	3	7	1	3
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SUB	Q1-23	Q1-24	Q1-25	Q1-26	Q1-27	Q1-28	Q1-29	Q1-30	Q1-31	Q2-1	Q2-2	Q2-3	Q2-4	Q2-5	Q2-6	Q2-7	Q2-8	Q2-9	Q2-10	Q2-11	Q2-12	Q2-13
1	6	4	3	1	1	5	5	2	2	7	7	5	6	6	6	6	5	6	2	4	6	2
2	6	2	4	4	2	5	4	3	1	7	7	4	5	5	5	5	5	5	6	3	6	3
3	3	3	5	3	1	5	3	1	1	7	6	4	1	4	6	6	5	4	3	2	5	3
4	5	3	4	3	3	3	3	6	4	7	7	3	4	4	6	5	5	5	3	4	5	4
5	4	4	5	3	6	4	6	1	1	6	6	4	7	6	7	7	6	2	4	2	6	5
6	5	4	2	3	1	2	4	1	1	6	6	2	2	3	5	5	5	5	4	4	5	5
7	6	2	4	4	3	5	5	1	1	6	7	4	7	5	5	5	6	4	3	3	5	5
8	5	4	4	4	2	2	5	1	1	6	7	4	6	4	6	6	5	5	3	2	6	2
9	5	6	6	6	4	6	4	6	3	5	7	1	1	2	5	4	4	2	7	5	4	5
10	5	2	7	5	1	2	7	6	5	5	6	5	6	6	6	7	5	5	7	2	6	4
11	6	7	6	2	1	7	6	4	1	5	6	2	3	4	4	5	5	3	2	4	5	4
12	6	4	2	5	2	1	4	1	1	5	6	2	5	2	1	2	5	4	3	2	5	4
13	6	2	5	3	1	6	4	3	2	7	5	1	1	5	4	4	1	2	2	3	5	3
14	6	5	2	3	2	1	2	1	1	7	5	4	2	2	3	3	1	3	7	1	3	5
15	3	4	1	1	1	1	1	1	1	7	5	1	7	3	5	4	1	2	4	3	2	4
16	5	7	2	1	1	2	2	1	1	7	5	1	3	3	3	5	3	3	4	3	5	3
17	6	4	2	2	4	2	5	6	5	6	5	6	5	5	6	6	4	5	6	3	6	4
18	7	7	7	7	6	1	7	1	1	6	5	5	4	3	4	4	1	1	4	1	4	4
19	6	4	2	2	1	7	4	1	1	6	5	1	1	4	5	7	1	4	4	6	4	2
20	4	6	2	2	3	4	7	1	4	6	5	1	6	5	4	4	1	6	4	1	5	3
21	4	5	2	2	2	3	2	2	2	5	5	2	5	4	3	4	1	3	6	5	2	5
22	6	2	6	5	2	5	7	2	2	5	5	5	6	3	3	6	1	5	4	3	6	4
23	2	6	5	2	3	7	4	7	6	5	5	1	1	1	5	6	1	5	6	4	4	3
24	3	5	6	2	7	2	2	5	5	5	5	1	1	3	3	4	1	2	4	2	3	5
25	4	6	1	1	1	7	4	5	1	7	5	1	4	2	3	5	1	5	5	2	4	5
26	2	3	5	5	5	6	7	7	6	7	5	5	5	6	6	7	2	6	5	3	6	2
27	5	4	4	1	3	4	1	7	5	7	5	1	6	5	2	5	1	5	4	3	5	3
28	6	4	5	4	1	5	7	7	7	7	5	1	1	4	3	3	1	1	6	1	5	4
29	2	6	2	2	4	7	5	1	1	7	5	1	1	3	5	5	1	5	4	2	5	4
31	5	5	5	5	1	3	5	4	2	7	6	2	6	5	5	5	5	5	5	4	6	6
32	5	2	5	6	4	3	5	1	1	7	7	1	1	6	6	5	6	5	3	4	5	6
33	3	3	6	4	5	4	4	2	1	7	7	2	2	2	4	6	6	2	4	4	5	3
34	7	2	4	2	2	5	6	2	2	7	7	1	4	3	6	6	7	5	2	3	5	3
35	5	2	3	2	1	5	5	1	1	6	5	2	6	5	4	5	1	3	4	4	5	4
36	5	3	6	4	4	3	5	3	1	6	5	1	4	5	4	4	4	4	4	3	5	2
37	6	6	2	2	1	3	7	3	2	6	5	1	1	5	5	3	1	6	6	5	5	6
38	6	6	5	7	5	1	2	5	1	6	5	7	7	6	4	5	1	6	3	3	5	6
39	6	3	6	6	1	6	5	3	2	6	5	3	5	4	5	3	6	5	2	2	3	2
40	5	6	5	3	1	5	4	1	1	6	7	3	4	4	6	5	4	3	6	3	5	3
41	6	3	1	1	4	6	6	1	1	6	7	4	4	5	5	5	5	6	5	4	4	2
42	6	4	3	2	1	1	4	1	1	6	6	2	2	4	4	5	5	7	4	4	6	6
43	6	3	6	5	5	2	5	1	1	6	6	4	6	5	6	6	4	5	5	2	6	2
44	5	6	4	7	1	4	4	1	1	6	6	2	2	3	3	5	1	3	6	4	5	4
45	6	3	1	1	1	6	5	1	1	5	5	1	2	3	2	5	1	1	2	2	5	4

46	3	6	2	2	1	7	2	1	4	5	5	2	7	6	4	2	1	5	2	2	5	1
47	2	3	2	2	1	5	4	1	1	5	5	1	4	4	4	1	1	5	2	1	4	3
48	5	2	5	5	2	5	7	4	6	5	5	1	1	5	2	5	1	2	6	2	3	1
49	6	3	1	1	1	2	5	1	1	5	5	4	5	6	5	5	5	5	6	2	5	6
50	5	7	5	1	1	5	5	1	1	5	7	4	6	5	5	6	6	6	6	4	5	3
51	5	5	5	5	3	4	5	6	5	5	7	5	3	3	4	5	3	5	5	2	5	2
52	7	2	7	3	1	6	7	4	3	5	7	1	4	2	5	6	6	1	1	1	6	4
53	4	4	2	2	2	4	6	2	1	5	6	3	4	4	5	6	3	5	7	4	5	6
54	6	3	5	3	1	1	5	6	4	5	6	1	1	4	5	6	5	2	4	5	6	5
55	0	0	0	0	0	0	0	0	0	3	3	-3	2	-2	1	1	1	-1	0	0	0	1
56	0	0	0	0	0	0	0	0	0	3	3	-3	3	1	2	2	1	1	2	2	0	0
57	0	0	0	0	0	0	0	0	0	3	3	-2	-1	0	1	1	0	1	-2	1	2	-1
58	0	0	0	0	0	0	0	0	0	3	3	-2	2	0	2	2	0	2	-2	1	1	0
59	0	0	0	0	0	0	0	0	0	3	3	-3	-1	-2	-2	0	0	-1	-2	2	-1	0
60	0	0	0	0	0	0	0	0	0	3	3	-2	0	1	-1	0	1	1	0	1	-1	0
61	0	0	0	0	0	0	0	0	0	3	3	-3	3	1	1	1	1	1	0	2	1	-2
62	0	0	0	0	0	0	0	0	0	3	3	-3	2	0	2	2	2	0	2	2	3	2
63	0	0	0	0	0	0	0	0	0	3	3	1	1	1	0	-1	-1	-1	0	2	-1	1
64	0	0	0	0	0	0	0	0	0	3	3	-3	3	1	2	3	0	3	-2	2	2	-2
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SUB	Q2-14	Q2-15	Q2-16	Q2-17	Q2-18	Q2-19	Q2-20	Q2-21	Q2-22	Q2-23	Q2-24	Q2-25	Q2-26	Q2-27	Q2-28	Q2-29	Q2-30	Q2-31	Q2-32	Q2-33	SUM-ITQ	ITQ (NOM)
1	6	6	7	7	6	6	6	6	1	5	6	4	5	7	6	3	3	6	6	1	158	Hi
2	6	6	5	6	5	6	5	4	5	3	5	6	6	5	3	6	6	6	3	6	129	Med
3	1	1	6	5	5	5	2	2	1	2	2	6	4	6	6	6	4	5	1	1	131	Med
4	4	4	5	5	6	4	4	4	5	5	5	4	4	4	4	5	4	3	3	1	122	Med
5	3	4	6	4	4	7	4	4	7	6	7	3	5	2	2	5	6	4	4	3	114	Lo
6	4	3	6	5	1	5	3	5	1	4	4	6	4	7	5	5	6	6	6	1	122	Med
7	3	5	6	1	1	5	6	5	1	3	7	2	6	5	5	6	5	3	5	1	123	Med
8	5	5	6	6	5	6	3	2	1	1	6	6	7	6	6	5	3	6	5	4	120	Lo
9	3	3	3	5	5	5	3	2	1	4	5	4	5	3	4	4	4	5	3	1	140	Hi
10	6	3	6	2	2	6	5	5	1	6	6	6	7	7	2	6	5	4	7	7	141	Hi
11	3	2	4	3	3	5	4	4	2	2	4	5	1	4	4	4	3	3	6	1	153	Hi
12	2	5	4	5	4	2	6	4	1	1	6	7	6	7	4	4	4	4	5	1	98	Lo
13	2	1	4	1	1	2	2	1	1	1	5	3	4	7	5	5	5	4	5	5	135	Med
14	3	3	2	3	1	3	2	3	3	1	3	5	1	5	6	3	5	5	5	1	105	Lo
15	2	6	5	1	1	4	3	4	4	1	4	4	4	6	5	4	1	6	1	1	91	Lo
16	3	4	5	3	3	5	3	5	5	3	3	4	5	3	5	3	3	5	3	1	119	Lo
17	5	6	5	4	4	5	4	6	3	2	5	4	6	5	5	5	4	5	4	2	119	Lo
18	1	1	3	1	1	3	3	3	3	7	4	1	1	1	1	1	7	1	1	1	151	Hi
19	4	1	6	1	4	4	3	4	1	1	5	7	7	7	4	1	7	7	2	1	131	Med
20	5	1	6	1	1	4	2	1	1	1	4	7	6	7	7	6	5	7	1	1	114	Lo
21	2	2	4	1	1	2	2	4	3	1	4	5	6	5	5	5	6	3	2	1	101	Lo
22	3	3	3	1	1	6	2	3	1	3	5	6	5	7	3	3	6	6	6	1	163	Hi
23	6	6	6	1	1	5	4	5	1	5	6	5	3	5	5	5	3	5	5	1	138	Hi
24	3	5	4	1	1	5	3	3	1	5	5	6	6	6	4	6	4	6	5	1	125	Med
25	2	4	4	1	1	4	2	2	1	1	4	7	6	7	6	3	4	4	2	1	121	Lo
26	6	5	6	1	1	6	5	5	3	7	6	2	2	5	5	3	3	5	3	7	144	Hi
27	4	4	6	1	1	4	3	4	1	3	5	4	4	5	5	4	5	5	4	3	151	Hi
28	5	4	6	1	1	5	2	1	1	5	5	2	4	4	4	2	4	4	6	7	151	Hi
29	3	3	3	1	1	4	2	1	1	4	5	2	4	6	1	3	5	3	4	1	121	Lo
31	5	6	5	6	4	6	4	3	4	3	3	4	6	6	5	6	5	6	4	5	128	Med
32	5	4	6	5	6	6	4	4	4	4	5	5	7	7	7	7	7	6	4	1	151	Hi
33	1	2	6	6	5	5	3	5	2	3	5	4	5	4	6	4	7	1	5	4	129	Med
34	4	1	6	5	4	5	5	1	1	4	6	3	6	7	4	4	6	3	2	5	144	Hi
35	6	6	5	1	1	6	2	3	2	3	5	3	2	5	4	2	5	6	4	1	114	Lo
36	5	4	5	1	1	5	3	1	1	1	3	4	3	5	5	6	3	5	1	1	143	Hi
37	6	7	6	1	1	6	2	3	1	2	6	6	7	7	5	7	1	7	4	1	150	Hi
38	6	6	6	1	1	6	6	5	6	1	5	7	7	7	7	6	7	7	2	1	122	Med
39	6	6	6	1	1	3	3	2	2	2	3	7	7	6	6	3	2	7	5	1	134	Med
40	5	3	5	4	5	6	4	3	3	4	6	3	4	3	4	4	4	3	6	3	121	Lo
41	4	5	5	6	4	6	3	5	2	2	2	7	6	7	4	7	4	6	1	1	123	Med
42	4	4	6	6	4	6	4	6	2	1	6	1	5	7	1	7	7	4	1	1	105	Lo
43	5	5	6	4	5	6	4	5	1	6	7	4	4	6	4	4	4	4	6	1	145	Hi
44	3	3	5	5	4	5	3	3	2	4	5	5	6	3	6	2	4	6	3	6	124	Med
45	3	4	4	1	1	3	2	1	1	1	2	7	2	7	4	4	2	4	1	1	116	Lo

46	4	2	6	1	1	6	2	2	4	1	4	7	6	7	6	1	6	6	1	1	123	Med
47	2	6	6	1	1	4	2	4	2	1	4	3	3	7	6	7	7	7	3	1	114	Lo
48	5	4	4	2	1	5	5	5	1	6	2	2	2	2	1	7	6	1	6	1	135	Med
49	5	5	6	1	1	5	5	1	1	1	5	6	4	5	4	3	4	6	5	1	126	Med
50	3	6	6	6	5	6	4	4	1	2	5	7	7	7	7	6	4	7	4	1	127	Med
51	3	4	4	5	5	3	3	4	3	5	5	5	3	3	2	3	5	5	5	5	139	Hi
52	4	3	3	4	4	4	3	4	1	2	5	4	4	6	7	7	7	4	5	1	147	Hi
53	5	6	6	6	5	6	3	5	1	2	6	4	5	6	5	6	4	6	7	1	127	Med
54	2	5	6	4	4	6	3	5	1	5	6	6	4	6	4	7	4	6	7	1	113	Lo
55	-1	0	1	1	-3	0	-3	-3	-3	-1	2	-3	0	3	0	0	1	1	0	-1	0	
56	1	1	1	2	1	2	-2	-2	-3	-1	1	-1	0	2	1	-2	0	1	-1	-2	0	
57	1	1	0	-1	0	2	-2	-2	-3	-1	2	1	1	0	0	1	0	0	-1	-1	0	
58	0	1	2	2	1	0	-1	1	-1	0	-1	-1	-1	2	0	0	0	0	0	-2	0	
59	-2	0	1	2	1	-1	-1	-2	-3	1	-1	2	1	-1	-1	0	1	-2	-2	2	0	
60	-1	-2	0	1	-1	0	-1	-2	-2	-1	0	0	-2	1	1	-1	-1	0	0	-3	0	
61	1	3	3	2	1	2	-2	-3	-3	-3	1	-1	-2	3	3	-3	1	0	2	-3	0	
62	-1	2	1	3	1	3	1	0	-3	0	1	-2	1	2	2	2	0	2	1	2	0	
63	0	1	1	2	1	0	1	3	-3	-2	1	1	0	2	1	-1	0	-2	0	-2	0	
64	1	1	2	1	1	2	1	-3	-3	-3	1	-2	2	3	3	-2	3	3	-3	-3	0	
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

SUB	SUM -PQ	N&W VEV	N&W REV	N&W VEA	N&W REA	N&W VET	N&W VET	P1 VV	P1 VA	P1 RV	P1 RA	P2 VV	P2 VA	P2 RV	P2 RA	P3 VV	P3 VA	P3 RV	P3 RA
1	171	48.2	9.6	38.1	33.3	43.2	21.5	0.0	0.0	30.6	34.4	20.6	0.5	0.0	0.0	43.8	20.0	0.0	0.0
2	169	68.3	28.1	39.9	37.0	54.1	32.6	0.0	0.0	41.7	40.6	35.3	2.5	0.0	0.0	34.4	17.5	0.0	0.0
3	127	19.0	5.3	16.7	7.4	17.9	6.3	0.0	0.0	16.7	12.5	17.6	0.5	0.0	0.0	12.5	5.0	0.0	0.0
4	145	36.0	7.0	42.9	7.4	39.5	7.2	0.0	0.0	22.2	12.5	26.5	1.5	0.0	0.0	18.8	10.0	0.0	0.0
5	158	33.6	32.5	33.4	72.2	33.5	52.3	0.0	0.0	50.0	43.8	23.5	1.5	10.0	16.7	18.8	15.0	0.0	0.0
6	144	82.2	7.0	54.8	14.8	68.5	10.9	0.0	0.0	22.2	25.0	44.1	1.0	0.0	0.0	43.8	25.0	0.0	0.0
7	146	54.3	3.5	38.1	7.4	46.2	5.5	0.0	0.0	11.1	12.5	35.3	1.0	0.0	0.0	31.3	15.0	0.0	0.0
8	156	30.5	9.6	72.7	20.4	51.6	15.0	0.0	0.0	30.6	34.4	17.6	2.0	0.0	0.0	31.3	20.0	0.0	0.0
9	124	50.6	5.3	42.9	11.1	46.8	8.2	0.0	0.0	16.7	18.8	32.4	1.5	0.0	0.0	25.0	15.0	0.0	0.0
10	169	60.5	26.3	29.8	33.3	45.1	29.8	0.0	0.0	36.1	34.4	32.4	0.5	0.0	0.0	31.3	15.0	0.0	0.0
11	119	42.7	7.9	39.3	11.1	41.0	9.5	0.0	0.0	25.0	18.8	23.5	2.5	0.0	0.0	31.3	10.0	0.0	0.0
12	128	76.2	10.5	28.6	22.2	52.4	16.4	0.0	0.0	33.3	37.5	38.2	0.8	0.0	0.0	37.5	20.0	0.0	0.0
13	107	40.8	0.0	8.3	0.0	24.6	0.0	0.0	0.0	0.0	0.0	32.4	0.0	0.0	0.0	18.8	5.0	0.0	0.0
14	109	25.7	8.8	8.3	14.8	17.0	11.8	0.0	0.0	27.8	25.0	17.6	0.0	0.0	0.0	18.8	5.0	0.0	0.0
15	115	39.0	5.3	8.3	11.1	23.7	8.2	0.0	0.0	16.7	18.8	20.6	0.0	0.0	0.0	25.0	5.0	0.0	0.0
16	122	56.0	3.5	8.3	7.4	32.2	5.5	0.0	0.0	11.1	12.5	32.4	0.0	0.0	0.0	25.0	5.0	0.0	0.0
17	156	53.6	5.3	16.7	27.8	35.2	16.5	0.0	0.0	16.7	25.0	29.4	0.0	0.0	0.0	25.0	10.0	0.0	0.0
18	91	53.0	10.5	25.0	22.2	39.0	16.4	0.0	0.0	33.3	37.5	29.4	0.0	0.0	0.0	37.5	15.0	0.0	0.0
19	127	49.5	21.9	16.7	27.8	33.1	24.9	0.0	0.0	22.2	25.0	35.3	0.0	0.0	0.0	18.8	10.0	0.0	0.0
20	125	68.4	20.6	21.4	30.6	44.9	25.6	0.0	0.0	36.1	34.4	38.2	0.5	10.0	16.7	31.3	10.0	0.0	0.0
21	114	68.7	28.1	16.7	35.2	42.7	31.6	0.0	0.0	41.7	37.5	41.2	0.0	0.0	0.0	31.3	10.0	0.0	0.0
22	130	56.2	12.3	16.7	22.2	36.4	17.2	0.0	0.0	33.3	31.3	32.4	0.0	10.0	16.7	31.3	10.0	0.0	0.0
23	130	43.2	10.5	29.8	18.5	36.5	14.5	0.0	0.0	33.3	31.3	26.5	0.5	0.0	0.0	37.5	15.0	0.0	0.0
24	119	37.1	23.7	16.7	44.4	26.9	34.1	0.0	0.0	27.8	31.3	23.5	0.0	0.0	0.0	25.0	10.0	0.0	0.0
25	115	33.6	7.0	8.3	11.1	21.0	9.1	0.0	0.0	22.2	18.8	23.5	0.0	0.0	0.0	18.8	5.0	0.0	0.0
26	151	16.2	27.2	0.0	35.2	8.1	31.2	0.0	0.0	38.9	37.5	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	127	43.8	12.3	16.7	22.2	30.2	17.2	0.0	0.0	38.9	37.5	23.5	0.0	0.0	0.0	31.3	10.0	0.0	0.0
28	115	60.5	10.5	8.3	51.8	34.4	31.2	0.0	0.0	33.3	31.3	38.2	0.0	0.0	16.7	18.8	5.0	0.0	0.0
29	105	60.8	34.2	21.4	63.0	41.1	48.6	0.0	0.0	50.0	50.0	32.4	0.5	10.0	16.7	37.5	10.0	3.6	16.7
31	163	36.0	7.9	51.2	16.7	43.6	12.3	0.0	0.0	25.0	28.1	23.5	1.0	0.0	0.0	25.0	25.0	0.0	0.0
32	166	53.0	8.8	59.5	14.8	56.3	11.8	0.0	0.0	22.2	25.0	32.4	1.5	10.0	0.0	31.3	25.0	0.0	0.0
33	137	46.3	13.2	42.9	20.4	44.6	16.8	0.0	0.0	41.7	34.4	29.4	0.5	0.0	0.0	31.3	30.0	0.0	0.0
34	141	48.2	7.0	34.5	14.8	41.4	10.9	0.0	0.0	22.2	25.0	29.4	1.0	0.0	0.0	25.0	15.0	0.0	0.0
35	126	37.9	32.5	8.3	38.9	23.1	35.7	0.0	0.0	44.4	37.5	20.6	0.0	10.0	16.7	25.0	5.0	3.6	0.0
36	114	31.3	35.1	16.7	63.0	24.0	49.0	0.0	0.0	38.9	43.8	20.6	0.0	20.0	33.3	18.8	10.0	8.9	16.7
37	141	42.5	17.5	13.1	29.6	27.8	23.6	0.0	0.0	33.3	31.3	30.9	0.5	20.0	33.3	12.5	5.0	7.1	16.7
38	164	70.8	41.2	21.4	42.6	46.1	41.9	0.0	0.0	44.4	37.5	44.1	0.5	10.0	16.7	25.0	10.0	21.4	16.7
39	130	44.6	39.5	8.3	42.6	26.5	41.0	0.0	0.0	38.9	37.5	26.5	0.0	20.0	16.7	18.8	5.0	17.9	16.7
40	141	65.2	15.8	38.1	42.6	51.7	29.2	0.0	0.0	44.4	43.8	29.4	0.5	10.0	16.7	50.0	20.0	0.0	0.0
41	149	33.6	10.5	29.8	18.5	31.7	14.5	0.0	0.0	33.3	31.3	20.6	1.0	0.0	0.0	25.0	15.0	0.0	0.0
42	144	50.6	35.1	46.4	40.7	48.5	37.9	0.0	0.0	47.2	40.6	29.4	1.0	10.0	16.7	31.3	15.0	7.1	0.0
43	154	34.8	34.2	21.4	35.2	28.1	34.7	0.0	0.0	33.3	31.3	26.5	1.0	20.0	16.7	12.5	5.0	10.7	0.0
44	133	66.5	28.9	78.6	42.6	72.5	35.8	0.0	0.0	38.9	43.8	35.3	1.3	0.0	0.0	43.8	30.0	7.1	16.7
45	93	51.3	16.7	8.3	24.1	29.8	20.4	0.0	0.0	30.6	28.1	23.5	0.0	20.0	16.7	31.3	5.0	7.1	16.7

46	121	56.1	13.2	16.7	24.1	36.4	18.6	0.0	0.0	36.1	34.4	30.9	0.0	0.0	0.0	31.3	10.0	3.6	16.7
47	117	47.0	10.5	25.0	18.5	36.0	14.5	0.0	0.0	33.3	31.3	26.5	0.0	0.0	0.0	25.0	15.0	0.0	0.0
48	107	29.4	8.8	16.7	18.5	23.0	13.6	0.0	0.0	16.7	18.8	20.6	0.0	10.0	16.7	25.0	10.0	3.6	16.7
49	138	42.6	37.7	4.8	75.9	23.7	56.8	0.0	0.0	38.9	37.5	25.0	0.5	10.0	33.3	12.5	0.0	17.9	16.7
50	166	29.4	32.5	38.1	42.6	33.7	37.5	0.0	0.0	38.9	43.8	20.6	1.3	20.0	16.7	25.0	10.0	3.6	0.0
51	134	31.3	8.8	25.0	11.1	28.1	9.9	0.0	0.0	27.8	18.8	23.5	0.5	0.0	0.0	12.5	10.0	0.0	0.0
52	131	50.6	17.5	25.0	42.6	37.8	30.1	0.0	0.0	38.9	37.5	38.2	0.5	20.0	16.7	12.5	10.0	3.6	16.7
53	158	58.9	28.9	50.0	42.6	54.4	35.8	0.0	0.0	33.3	37.5	35.3	1.0	10.0	16.7	37.5	15.0	3.6	16.7
54	147	68.7	19.3	25.0	25.9	46.9	22.6	0.0	0.0	38.9	37.5	41.2	0.5	20.0	16.7	31.3	10.0	7.1	0.0
55	-3	76.7	0.0	54.8	0.0	65.7	0.0	0.0	0.0	0.0	0.0	38.2	0.5	0.0	0.0	50.0	25.0	0.0	0.0
56	16	62.1	0.0	42.3	0.0	52.2	0.0	0.0	0.0	0.0	0.0	36.8	1.0	0.0	0.0	34.4	15.0	0.0	0.0
57	4	63.8	0.0	41.7	0.0	52.7	0.0	0.0	0.0	0.0	0.0	36.8	0.5	0.0	0.0	37.5	17.5	0.0	0.0
58	14	60.8	0.0	61.9	0.0	61.4	0.0	0.0	0.0	0.0	0.0	32.4	1.5	0.0	0.0	37.5	22.5	0.0	0.0
59	-9	37.3	0.0	57.2	0.0	47.2	0.0	0.0	0.0	0.0	0.0	26.5	1.0	0.0	0.0	25.0	20.0	0.0	0.0
60	-8	51.8	0.0	42.3	0.0	47.0	0.0	0.0	0.0	0.0	0.0	32.4	1.3	0.0	0.0	28.1	12.5	0.0	0.0
61	14	44.0	0.0	70.3	0.0	57.1	0.0	0.0	0.0	0.0	0.0	29.4	2.5	0.0	0.0	25.0	25.0	0.0	0.0
62	38	60.9	0.0	38.1	0.0	49.5	0.0	0.0	0.0	0.0	0.0	32.4	0.5	0.0	0.0	43.8	20.0	0.0	0.0
63	12	23.8	0.0	33.3	0.0	28.6	0.0	0.0	0.0	0.0	0.0	20.6	0.8	0.0	0.0	18.8	10.0	0.0	0.0
64	20	39.5	0.0	21.4	0.0	30.5	0.0	0.0	0.0	0.0	0.0	26.5	0.5	0.0	0.0	25.0	10.0	0.0	0.0
65	0	0.0	93.0	0.0	63.0	0.0	78.0	0.0	0.0	38.9	43.8	0.0	0.0	50.0	33.3	0.0	0.0	21.4	16.7
66	0	0.0	55.7	0.0	81.5	0.0	68.6	0.0	0.0	47.2	40.6	0.0	0.0	35.0	50.0	0.0	0.0	25.0	16.7
67	0	0.0	29.8	0.0	29.6	0.0	29.7	0.0	0.0	41.7	37.5	0.0	0.0	25.0	16.7	0.0	0.0	25.0	16.7
68	0	0.0	40.8	0.0	50.0	0.0	45.4	0.0	0.0	44.4	43.8	0.0	0.0	40.0	33.3	0.0	0.0	25.0	16.7
69	0	0.0	29.8	0.0	29.6	0.0	29.7	0.0	0.0	38.9	31.3	0.0	0.0	40.0	33.3	0.0	0.0	21.4	16.7
70	0	0.0	47.4	0.0	91.7	0.0	69.5	0.0	0.0	50.0	46.9	0.0	0.0	35.0	50.0	0.0	0.0	21.4	16.7

SUB	P2-P1 VV	P2-P1 VA	P2-P1 RV	P2-P1 RA	P3-P2 VV	P3-P2 VA	P3-P2 RV	P3-P2 RA	P2 RA-VA	P2 RV-VV	P3 RA-VA	P3 RV-VV
1	20.6	0.5	30.6	34.4	23.2	19.5	0.0	0.0	0.5	43.8	20.0	43.8
2	35.3	2.5	41.7	40.6	0.9	15.0	0.0	0.0	2.5	34.4	17.5	34.4
3	17.6	0.5	16.7	12.5	5.1	4.5	0.0	0.0	0.5	12.5	5.0	12.5
4	26.5	1.5	22.2	12.5	7.7	8.5	0.0	0.0	1.5	18.8	10.0	18.8
5	23.5	1.5	40.0	27.1	4.8	13.5	10.0	16.7	15.2	8.8	15.0	18.8
6	44.1	1.0	22.2	25.0	0.4	24.0	0.0	0.0	1.0	43.8	25.0	43.8
7	35.3	1.0	11.1	12.5	4.0	14.0	0.0	0.0	1.0	31.3	15.0	31.3
8	17.6	2.0	30.6	34.4	13.6	18.0	0.0	0.0	2.0	31.3	20.0	31.3
9	32.4	1.5	16.7	18.8	7.4	13.5	0.0	0.0	1.5	25.0	15.0	25.0
10	32.4	0.5	36.1	34.4	1.1	14.5	0.0	0.0	0.5	31.3	15.0	31.3
11	23.5	2.5	25.0	18.8	7.7	7.5	0.0	0.0	2.5	31.3	10.0	31.3
12	38.2	0.8	33.3	37.5	0.7	19.3	0.0	0.0	0.8	37.5	20.0	37.5
13	32.4	0.0	0.0	0.0	13.6	5.0	0.0	0.0	0.0	18.8	5.0	18.8
14	17.6	0.0	27.8	25.0	1.1	5.0	0.0	0.0	0.0	18.8	5.0	18.8
15	20.6	0.0	16.7	18.8	4.4	5.0	0.0	0.0	0.0	25.0	5.0	25.0
16	32.4	0.0	11.1	12.5	7.4	5.0	0.0	0.0	0.0	25.0	5.0	25.0
17	29.4	0.0	16.7	25.0	4.4	10.0	0.0	0.0	0.0	25.0	10.0	25.0
18	29.4	0.0	33.3	37.5	8.1	15.0	0.0	0.0	0.0	37.5	15.0	37.5
19	35.3	0.0	22.2	25.0	16.5	10.0	0.0	0.0	0.0	18.8	10.0	18.8
20	38.2	0.5	26.1	17.7	7.0	9.5	10.0	16.7	16.2	21.3	10.0	31.3
21	41.2	0.0	41.7	37.5	9.9	10.0	0.0	0.0	0.0	31.3	10.0	31.3
22	32.4	0.0	23.3	14.6	1.1	10.0	10.0	16.7	16.7	21.3	10.0	31.3
23	26.5	0.5	33.3	31.3	11.0	14.5	0.0	0.0	0.5	37.5	15.0	37.5
24	23.5	0.0	27.8	31.3	1.5	10.0	0.0	0.0	0.0	25.0	10.0	25.0
25	23.5	0.0	22.2	18.8	4.8	5.0	0.0	0.0	0.0	18.8	5.0	18.8
26	14.7	0.0	38.9	37.5	14.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	23.5	0.0	38.9	37.5	7.7	10.0	0.0	0.0	0.0	31.3	10.0	31.3
28	38.2	0.0	33.3	14.6	19.5	5.0	0.0	16.7	16.7	18.8	5.0	18.8
29	32.4	0.5	40.0	33.3	5.1	9.5	6.4	0.0	16.2	27.5	6.7	33.9
31	23.5	1.0	25.0	28.1	1.5	24.0	0.0	0.0	1.0	25.0	25.0	25.0
32	32.4	1.5	12.2	25.0	1.1	23.5	10.0	0.0	1.5	21.3	25.0	31.3
33	29.4	0.5	41.7	34.4	1.8	29.5	0.0	0.0	0.5	31.3	30.0	31.3
34	29.4	1.0	22.2	25.0	4.4	14.0	0.0	0.0	1.0	25.0	15.0	25.0
35	20.6	0.0	34.4	20.8	4.4	5.0	6.4	16.7	16.7	15.0	5.0	21.4
36	20.6	0.0	18.9	10.4	1.8	10.0	11.1	16.7	33.3	1.3	6.7	9.8
37	30.9	0.5	13.3	2.1	18.4	4.5	12.9	16.7	32.8	7.5	11.7	5.4
38	44.1	0.5	34.4	20.8	19.1	9.5	11.4	0.0	16.2	15.0	6.7	3.6
39	26.5	0.0	18.9	20.8	7.7	5.0	2.1	0.0	16.7	1.3	11.7	0.9
40	29.4	0.5	34.4	27.1	20.6	19.5	10.0	16.7	16.2	40.0	20.0	50.0
41	20.6	1.0	33.3	31.3	4.4	14.0	0.0	0.0	1.0	25.0	15.0	25.0
42	29.4	1.0	37.2	24.0	1.8	14.0	2.9	16.7	15.7	21.3	15.0	24.1
43	26.5	1.0	13.3	14.6	14.0	4.0	9.3	16.7	15.7	7.5	5.0	1.8
44	35.3	1.3	38.9	43.8	8.5	28.8	7.1	16.7	1.3	43.8	13.3	36.6
45	23.5	0.0	10.6	11.5	7.7	5.0	12.9	0.0	16.7	11.3	11.7	24.1

46	30.9	0.0	36.1	34.4	0.4	10.0	3.6	16.7	0.0	31.3	6.7	27.7
47	26.5	0.0	33.3	31.3	1.5	15.0	0.0	0.0	0.0	25.0	15.0	25.0
48	20.6	0.0	6.7	2.1	4.4	10.0	6.4	0.0	16.7	15.0	6.7	21.4
49	25.0	0.5	28.9	4.2	12.5	0.5	7.9	16.7	32.8	2.5	16.7	5.4
50	20.6	1.3	18.9	27.1	4.4	8.8	16.4	16.7	15.4	5.0	10.0	21.4
51	23.5	0.5	27.8	18.8	11.0	9.5	0.0	0.0	0.5	12.5	10.0	12.5
52	38.2	0.5	18.9	20.8	25.7	9.5	16.4	0.0	16.2	7.5	6.7	8.9
53	35.3	1.0	23.3	20.8	2.2	14.0	6.4	0.0	15.7	27.5	1.7	33.9
54	41.2	0.5	18.9	20.8	9.9	9.5	12.9	16.7	16.2	11.3	10.0	24.1
55	38.2	0.5	0.0	0.0	11.8	24.5	0.0	0.0	0.5	50.0	25.0	50.0
56	36.8	1.0	0.0	0.0	2.4	14.0	0.0	0.0	1.0	34.4	15.0	34.4
57	36.8	0.5	0.0	0.0	0.7	17.0	0.0	0.0	0.5	37.5	17.5	37.5
58	32.4	1.5	0.0	0.0	5.1	21.0	0.0	0.0	1.5	37.5	22.5	37.5
59	26.5	1.0	0.0	0.0	1.5	19.0	0.0	0.0	1.0	25.0	20.0	25.0
60	32.4	1.3	0.0	0.0	4.2	11.3	0.0	0.0	1.3	28.1	12.5	28.1
61	29.4	2.5	0.0	0.0	4.4	22.5	0.0	0.0	2.5	25.0	25.0	25.0
62	32.4	0.5	0.0	0.0	11.4	19.5	0.0	0.0	0.5	43.8	20.0	43.8
63	20.6	0.8	0.0	0.0	1.8	9.3	0.0	0.0	0.8	18.8	10.0	18.8
64	26.5	0.5	0.0	0.0	1.5	9.5	0.0	0.0	0.5	25.0	10.0	25.0
65	0.0	0.0	11.1	10.4	0.0	0.0	28.6	16.7	33.3	50.0	16.7	21.4
66	0.0	0.0	12.2	9.4	0.0	0.0	10.0	33.3	50.0	35.0	16.7	25.0
67	0.0	0.0	16.7	20.8	0.0	0.0	0.0	0.0	16.7	25.0	16.7	25.0
68	0.0	0.0	4.4	10.4	0.0	0.0	15.0	16.7	33.3	40.0	16.7	25.0
69	0.0	0.0	1.1	2.1	0.0	0.0	18.6	16.7	33.3	40.0	16.7	21.4
70	0.0	0.0	15.0	3.1	0.0	0.0	13.6	33.3	50.0	35.0	16.7	21.4

APPENDIX B. EXPERIMENT OUTLINE

1. EXPERIMENT PRE-CHECK LIST

1. _____Unplug Telephone in Lab
2. _____Section Off Lab Area
3. _____Make sure no unnecessary noise is around in Lab
4. _____Place TV and VCR by 3 screen TV and plug in
5. _____Turn power on to TV and VCR
6. _____Ensure Headphones are pluged in and ready in treatment gets sound
7. _____Ensure Flybox and Headtracker devices are plugged into ttyd3 and ttyd2
8. _____Ensure Table and Chair are in front of 3 screen display
9. _____Start-up appropriate experiment program

   A. _____Flatscreen

      1) _____Ensure Screen is plugged in
      2) _____Ensure Flatscreen and Flybox are on table in front of 3 screen
      3) _____Start Program ezs_rtm_pf20_62 -s UFO_Flatscreen.set -S -P3 -L
      4) _____Check Flybox
      5) _____Load recording F1 KEY
      6) _____Play HOME KEY
      7) _____Stop END KEY
      8) _____Rewind INSERT KEY

   B. _____3 Screen

      1) _____Ensure 3 Screen TVs are plugged in and on
      2) _____Ensure Flybox is on table in front of 3 screen TVs
      3) _____Start Program ezs_rtm_pf20_62 -s UFO_3screen.set -S -P3 -L
      4) _____Check Flybox
      5) _____Load recording F1 KEY
      6) _____Play HOME KEY
      7) _____Stop END KEY
      8) _____Rewind INSERT KEY

   C. _____HMD

1) _____Ensure HMD is plugged in

2) _____Ensure Flatscreen and Flybox are on table in front of 3 screen

3) _____Start Program ezs_rtm_pf20_62 -s UFO_HMD.set -S -P3 -L

4) _____Check Flybox

5) _____Load recording F1 KEY

6) _____Play HOME KEY

7) _____Stop END KEY

8) _____Rewind INSERT KEY

10. _____Place "Do Not Disturb Sign" on Partition in Lab

11. _____Place Chair and table in Video Lab for subject

12. _____Place "Do Not Disturb Sign" on Door to Video Lab

13. _____Place Video In VCR and place on pause

14. _____Ensure headphones are plugged in and work

15. _____Have subject read experiment overview and voluntary consent

16. _____Have subject sign first part of consent form

17. _____Ask is subject has a cold that would effect his hearing

18. _____Tell subject to take a bathroom break now if needed before continuing

19. _____Have subject turn-off any audible pagers, mobile phones, or watches

20. _____Start-up appropriate experiment program

21. _____Enter subject's data along with trial number.

22. _____Have subject sit in seat and adjust height as appropriate

23. Start Camera

2. EXPERIMENT POST-CHECK LIST

1. _____Remove Participants Headphones or HMD
2. _____Remove Participant from experimental area
3. _____Have subject fill out Post-experiment questions
   - A. _____Virtual Environment Quiz
   - B. _____Real Environment Quiz
   - C. _____Presence Questionaire

3. _____Answer any questions of the subject
4. _____Have subject sign last part of the consent form
5. _____Give copy of consent form to subject.
6. _____Staple my business card to subject's copy of consent form
7. _____Thank subject for participating and dismiss
8. _____Check that data was captured properly
9. _____Place data file in data folder
10. _____Plug in Telephones

APPENDIX C. INBRIEFING SCRIPT

1. GENERAL

The scripts in this appendix appear in the same format utilized for the experiment. This appendix consists of two briefing scripts: In Briefing (not told about second stimuli) and In Briefing (told about second stimuli). Each subject receives the appropriate In Briefing. This appendix also contains the Debriefing hand out.

2. IN BRIEFING

EXPERIMENT IN BRIEFING

Welcome to the Naval Postgraduate School's Computer Science Department. My name is John Lawson and I would like to thank you for your assistance with today's experiment. The experiment deals with presence in a virtual environment.

This experiment is not a test of your intelligence or performance. Rather, it is a test to evaluate a variety of different immersive technological devices. (For Military Personnel) *Your performance will not be recorded in your personnel records but is intended for research purposes only.* All information collected is for academic research only and will be held in strict confidence.

Prior to starting the experiment, you will be asked to read and sign a consent form. Upon signing the consent form, you will take a 15-minute pre-questionnaire. After the test, you will be escorted to the Graphics Lab to go through the virtual environment. Upon completion of the VE, you will be brought back to this room to complete a couple of tests and a post questionnaire followed by a short debriefing. If there are no questions, please read and sign this consent form.

A. Experiment 1

Stage: You have been transferred to a new town. The company that you're working for has set you up with an automated realtor. The realtor is not interactive. It is going to show you around a town so you can find a place to live. A friend of yours will also be arriving soon and will need to find a place to live and you will be asked to escort her/him around the town. Remember as many details about the town as you can so you will be a help to your friend later.

If you have no questions will get started with the experiment.

B. Experiment 2

Stage: You have been transferred to a new town. The company that you're working for has set you up with an automated realtor. The realtor is not interactive. It is going to show you around a town so you can find a place to live. A friend of yours will also be arriving soon and will need to find a place to live and you will be asked to escort her/him around the town. Remember as many details about the town and the movie as you can. At the end of the experiment you will be given two test to measure how much you remembered about both environments. If you have no questions will get started with the experiment.

3. DEBRIEFING

The use of virtual environments in training and education has been an expanding field for the last two decades. With recent developments in computer technology, virtual environments are now able to provide much higher fidelity in audio and video modalities. To insure we are providing the user a high state of immersion or presence into the virtual environment, research is being conducted in order to place a scale on each immersive device we currently use today with virtual environments.

The study you have just completed is concerned with this concept of presence or immersion in a virtual environments. You were provided two stimuli and then quizzed on both the real environment stimuli and virtual environment stimuli to see how you divide your modality resources.

Twelve separate groups were examined in order to determine the different levels of presence in the virtual environment. The first six groups were not told about the real

environment stimuli. The last six groups were told about the real environment stimuli and that they would be quizzed on both environments.

The research personnel observed and recorded information based on the experience and behavior of the participants in order to gather the information equipped for the redesign and implementation of a more useful virtual model. The notes and observations collected will be used for the purpose of establishing standards for model development.

Your assistance in this project will contribute to the production of more useful virtual environments that provide users with a high degree of presence in the virtual environment. With the information gathered from your experience and the experience of other participants, we are discovering what people is necessary in order to provide the participant with a high degree of presence in a virtual environment. This information will assist in the design of future virtual reality models that will be adaptive to a variety of individual needs.

If you have any questions about this study, please ask or email me your questions. Until 30 July 1998, please do not discuss this experiment with anyone except our research personnel until about 30 July 1998. This is to prevent influencing any future subjects. Thank you for your participation in this study.

Additional information on this study can be obtained from, CPT John P. Lawson, at (408) 372-5634 or Email: jplawson@cs.nps.navy.mil.

Measuring Presence
in Virtual Environments

Last Name:________________________
Subject and Sequence Number:__________
Date:_____________________________

APPENDIX D. CONSENT FORMS

1. GENERAL

The forms in the appendix appear in the same format utilized for the experiment and do not follow the standard thesis format utilized in the chapters of this document. This appendix consists of three documents: Consent Form, Minimal Risk Consent Statement, and the Privacy Act Statement. Each subject is required to read and sign these documents before being allowed to participate in the study. A research monitor observes and verifies the signing of each document.

2. PARTICIPANT CONSENT FORM

PARTICIPANT CONSENT FORM

1. **Introduction**. Welcome to the NPSNET Research Group, Department of Computer Science, Naval Postgraduate School, Monterey, California. You are invited to participate in a study of presence in virtual environments. With information gathered from you and other participants, we hope to discover insight pertaining to the role that technological devices play in the sense of presence in virtual environments. We ask that you to read and sign this forms indicating that you have been informed of all aspects of this experiment and further agree to participate in the study. Please ask any questions you may have before signing.
2. **Background Information**. The Naval Postgraduate School NPSNET Research Group is conducting this study.
3. **Procedures.** If you agree to participate in this study, the researcher will explain the task in detail. There will be a pretest phase, virtual environment phase, and posttest phase, in which you will be asked to answer a number of questions related to the virtual environment.
4. **Risk and Benefits.** This research involves no risks or discomforts greater than those encountered in being a passenger in a car. The benefits to the participants are gaining information on virtual reality and contributing to current research in measuring presence in virtual reality environments.
5. **Compensation.** No tangible reward will be given. A copy of the results will be available to you at the conclusion of the experiment.
6. **Confidentiality.** The records of this study will be kept confidential. No information will be publicly accessible that would possibly identify you as a participant.
7. **Voluntary Nature of the Study.** If you agree to participate, you are free to withdraw from the study at any time without prejudice. You will be provided a copy of this form for your records.
8. **Points of Contact**. If you have any further questions or comments after the completion of the study, you may contact the research supervisor, John Lawson at (408) 372-5634 or (email jplawson@cs.nps.navy.mil).
9. **Statement of Consent**. I have read and understand the above information. All questions that I may have had have been answered to my satisfaction. I, of my own free will, agree to participate in this study.

____________________________ ______________

Participant's Signature Date

____________________________ ______________

Researcher's Signature Date

3. MINIMAL RISK CONSENT STATEMENT

MINIMAL RISK CONSENT STATEMENT

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943
MINIMAL RISK CONSENT STATEMENT

Subject: VOLUNTARY CONSENT TO BE A RESEARCH PARTICIPANT IN: Virtual Environments and Navigation in Natural Environments

1. I have read, understand and been provided "Information for Participants" that provides the details of the below acknowledgments.

2. I understand that this project involves research. An explanation of the purposes of the research, a description of procedures to be used, identification of experimental procedures, and the extended duration of my participation have been provided to me.

3. I understand that this project does not involve more than minimal risk. I have been informed of any reasonably foreseeable risks or discomforts to me.

4. I have been informed of any benefits to me or to others that may reasonably be expected from the research.

5. I have signed a statement describing the extent to which confidentiality of records identifying me will be maintained.

6. I have been informed of any compensation and/or medical treatments available if injury occurs and is so, what they consist of, or where further information may be obtained.

7. I understand that my participation in this project is voluntary, refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled. I also understand that I may discontinue participation at any time without penalty or loss of benefits to which I am otherwise entitled.

8. I understand that the individual to contact should I need answers to pertinent questions about the research is Rudy Darken, Ph.D., Principal Investigator, and about my rights as a research subject or concerning a research related injury is the Modeling Virtual Environments and Simulations Chairman. A full and responsive discussion of the elements of this project and my consent has taken place.

Medical Monitor: Flight Surgeon, Naval Postgraduate School

____
Signature of Principal Investigator Date

____
Signature of Volunteer Date

____
Signature of Witness Date

4. PRIVACY ACT STATMENT

PRIVACY ACT STATMENT

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943
PRIVACY ACT STATEMENT

1. Authority: Naval Instruction

2. Purpose: Presence and immersion information will be collected to enhance knowledge, or to develop tests, procedures, and equipment to improve the development of Virtual Environments.

3. Use: Presence and immersion information will be used for statistical analysis by the Departments of the Navy and Defense, and other U.S. Government agencies, provided this use is compatible with the purpose for which the information was collected. Use of the information may be granted to legitimate non-government agencies or individuals by the Naval Postgraduate School in accordance with the provisions of the Freedom of Information Act.

4. Disclosure/Confidentiality:

   a. I have been assured that my privacy will be safeguarded. I will be assigned a control or code number which thereafter will be the only identifying entry on any of the research records. The Principal Investigator will maintain the cross-reference between name and control number. It will be decoded only when beneficial to me or if some circumstances, which is not apparent at this time, would make it clear that decoding would enhance the value of the research data. In all cases, the provisions of the Privacy Act Statement will be honored.

   b. I understand that a record of the information contained in this Consent Statement or derived from the experiment described herein will be retained permanently at the Naval Postgraduate School or by higher authority. I voluntarily agree to its disclosure to agencies or individuals indicated in paragraph 3 and I have been informed that failure to agree to such disclosure may negate the purpose for which the experiment was conducted.

   c. I also understand that disclosure of the requested information, including my Social Security Number, is voluntary.

____

Signature of Volunteer Name, Grade/Rank (if applicable) DOB SSN Date

____

Signature of Witness Date

APPENDIX E. QUESTIONNAIRES AND TESTS

1. GENERAL

The items in the appendix appear in the same format utilized for the experiment and thus do not follow the standard thesis format utilized in the chapters of this document. This appendix consists of four documents: Pre-Questionnaire (ITQ), Virtual Environment Quiz, Real Environment Quiz, and a Post Questionnaie (PQ).

APPENDIX E-1. PRE - QUESTIONNAIRE

Pre-Questionnaire

Indicate your answer by circling the appropriate number on the seven-point scale paying close attention to the particular anchors at the ends and in the middle of each new scale.

1. Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks ?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

1. How easily can you switch your attention from a task in which you presently may be involved to a new task?

NOT SO EASILY			FAIRLY EASILY			QUITE EASILY
-3	-2	-1	0	+1	+2	+3

2. How frequently do you get emotionally involved (angry, sad or happy) in the news stories that you read or hear?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

3. How well do you feel today?

NOT WELL			PRETTY WELL			EXCELLENT
-3	-2	-1	0	+1	+2	+3

4. Do you easily become deeply involved in movies or tv dramas?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

5. Do you ever become so involved in a television program or book that people have problems getting your attention?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

6. How mentally alert do you feel at the present time?

NOT ALERT			MODERATELY			FULLY ALERT
-3	-2	-1	0	+1	+2	+3

7. Do you ever become so involved in a movie that you are not aware of things happening around you?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

8. How frequently do you find yourself closely identifying with the characters in a story line?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

9. Do you ever become so involved in a video game that it is as if you are inside the game rather that moving a joystick and watching the screen?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

10. On average, how many books do you read for enjoyment in a month?

NONE	1	2	3	4	5	MORE

11. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!)

Spy Novels	Fantasies	Science Fiction
Adventure Novels	Romance Novels	Historical Novels
Westerns	Mysteries	Other Fiction
Biographies	Autobiographies	Other non-Fiction

12. How physically fit do you feel today?

NOT FIT			MODERATELTY FIT			EXTREMELY FIT
-3	-2	-1	0	+1	+2	+3

13. How good are you at blocking out external distractions when you are involved in something?

NOT VERY GOOD			SOMEWHAT GOOD			VERY GOOD
-3	-2	-1	0	+1	+2	+3

14. When watching sports, do you ever become so involved in the game that you react as if you were one of the players or a spectator at the event?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

15. Do you ever become so involved in a daydream that you are not aware of things happening around you?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

16. Do you ever have dreams that are so real that you feel disoriented when you awake?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

17. When playing sports, do you become so involved in the game that you lose track of time?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

18. Are you easily disturbed when working at a task?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

19. How well do you concentrate on enjoyable activities?

NOT AT ALL			MODERATELY WELL			VERY WELL
-3	-2	-1	0	+1	+2	+3

20. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

21. How well do you concentrate on disagreeable tasks?

NOT AT ALL			MODERATELY WELL			VERY WELL
-3	-2	-1	0	+1	+2	+3

22. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

23. To what extent have you dwelled on personal problems in the last 48 hours?

NOT AT ALL			SOME			ENTIRELY
-3	-2	-1	0	+1	+2	+3

24. Have you ever gotten scared by something happening on a TV show or in a movie?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

25. Have you ever remained apprehensive or fearful long after watching a scary movie?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

26. Do you ever avoid carnival or fairgrounds rides because they are too scary?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

27. How frequently do you watch TV soap operas or documentaries?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

28. Do you ever become so involved in doing something that you lose all tack of time?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

29. Do you ever get motion sickness when reading in a car?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

30. Do you ever get motion sickness when rideing as a passenger in a car?

NEVER			OCCASIONALLY			OFTEN
-3	-2	-1	0	+1	+2	+3

APPENDIX E-2. POST VIRTUAL ENVIRONMENT QUIZE

Post-Virtual Environment Quiz

Answer all questions to the best of your abilities. If you do not know the answer, take your best guess.

1. Where did your trip begin?

2. What was the speed limit at the beginning of the trip

3. In what type of terrain were you riding?

4. How many railroad tracks did you cross?

5. What color was the chair you were sitting in?

6. What was the tallest structure in the town?

7. What type(s) of signs or road markings did you see?

8. What type of boat(s) were on the lake?

9. What color was the driver's shirt?

10. What company gas station(s) did you see?

11. What time of day did it appear to be?

12. Were the lights in the stores in town on or off?

13. What was the price of gas?

14. Were any houses or businesses for sale?

15. Were the streets marked passing or no passing zone?

16. Did you see any churches ? If so how many?

17. Was the road you were on two lane or four lane?

18. What color was the table in front of you?

19. What was the name or your driver?

20. What was the name of the company that employed your driver?

21. What was the name of the town?

22. What was the town population?

23. What was the town's expected future population?

24. What was the name of the drug store?

25. What did the sign say above the TV?

26. What was the reporter's name at the observatory outside of town?

27. What was the name of the observatory outside of town?

28. What was the professor's name at the S.E.T.I. observatory?

29. What was the cost per acre for the farmland outside of town?

30. What type(s) of warning(s) did the National Emergency Broadcasting System issue?

31. Whose farm did you see off to the right?

32. At what time did the first extraordinary occurrence happen?

33. What size on the Richter scale did the shock wave register?

34. How may TV's were in front of you?

35. What was the reporter's name reporting from the scene of the landing?

36. What was the name of the library?

37. What was directly across from the library?

38. Why was traffic being detoured in the middle of town?

39. What was the name of the roads where they were detouring traffic from?

40. What was the name brand of the TV's in front of you?

APPENDIX E-3. POST REAL ENVIRONMENT QUIZ

Post-Real Environment Quiz

Answer all questions to the best of your abilities. If you do not know the answer, take your best guess.

1. (VH/AH) What was the dog's name? (Gromit)
2. (VL/AL) What was the man/owner's name? (Wallace)
3. (VM) What was painted on the toaster? (Flowers)
4. (AH/VH) What is special about the day at the beginning of the show? (Gromit's b-day)
5. (VH/AH) What does the dog receive from his owner? (Techno-trousers, collar and leash)
6. (VM) What does the man have for breakfast the first day? (Toast with jam)
7. (VH) What is the border they take in? (Penguin)
8. (VM) What type of wallpaper is in the dog's room? (Bones)
9. (VM) What type of wallpaper does the border put up? (Fish)
10. (VL/AL) What is the name of the train? (905)
11. (VH/AH) Where is the train? (Runs through the house)
12. (VL) What is the dog doing when the border rings the door bell to apply for room? (crocheting)
13. (VM) What clothes does the man normally wear? (white shirt, vest)
14. (AM) Can you name any of the songs the border played in his room? (
15. (VL) What kind of cereal does the dog eat? (Korn Flakes)
16. (VL/AH) What does the man and the border share the night the dog leaves home? (Wine and cheese)
17. (VH/AH) What is the weather like when the dog leaves home? (Raining and stormy)
18. (VM) Where does the dog sleep when he leaves home? (Metal trash can in an alley)
19. (VM/AM) What disguise is the border wearing in the "Wanted" poster? (Chicken)
20. (VH/AM) What does the border want from the man? (Help steeling a diamond)
21. (VL) Where is this item that the border/burglar wants. (City Museum)

22. (VM) What kind of skeletons did you see inside the building where the item the burglar wants is located? (Dinosaurs)
23. (VH) What causes the burglar alarm to sound? (Ceiling block comes loose and allows the man's arm to swing through the laser)
24. (VM) What does the burglar lock the man in after the crime? (Wardrobe)
25. (VM) How does the dog and the man get out of this place? (Dog uses the techno-trousers to shake the wardrobe apart)
26. (VH) What does the dog capture the burglar in at the end? (A milk bottle)
27. (VM) Where does the burglar wind up locked? (Zoo)
28. (VM/AM) What is the burglar's name? (Feather McGraw)
29. (VH/AH) Why did the man take on a border in the first place? (Needed the money)
30. (VH/AH) Did the man take on another border; why did he or did he not? (The reward money took care of the bills - no he did not take on another border)

APPENDIX E-4. POST - QUESTIONNAIRE

Post-Questionnaire

Characterize your experience in the virtual environment, by circling one of the appropriate numbers on the seven-point scale, in accordance with the question content and descriptive labels. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer. ANSWER ALL QUESTIONS WITH REGARD TO YOUR EXPERIENCE IN THE EXPERIMENT.

1. Which output technique did you use?

   FLATSCREEN DISPLAY   3-SCREEN DISPLAY   HMD

2. W hat did you hear from the virtual environment?

   NO SOUND   MONO SOUND   SURROUND SOUND

3. How much were you able to control events?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

4. How responsive was the environment to actions that you initiated (or performed)?

NOT RESPONSIVE			MODERATELY RESPONSIVE			COMPLETELY RESPONSIVE
-3	-2	-1	0	+1	+2	+3

5. How natural did your interactions with the environment seem?

EXTREMELY ARTIFICIAL			BORDERLINE			COMPLETELY NATURAL
-3	-2	-1	0	+1	+2	+3

6. How completely were all of your senses engaged?

NOT ENGAGED			MILDLY ENGAGED			COMPLETELY ENGAGED
-3	-2	-1	0	+1	+2	+3

7. How much did the visual aspects of the environment involve you?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

8. How much did the auditory aspects of the environment involve you?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

9. How natural was the mechanism that controlled movement through the environment?

EXTREMELY ARTIFICIAL			BORDERLINE			COMPLETELY NATURAL
-3	-2	-1	0	+1	+2	+3

10. How aware were you of events occurring in the real world around you?

NOT AWARE			MILDLY AWARE			VERY AWARE
-3	-2	-1	0	+1	+2	+3

11. How aware were you of your display and control devices?

NOT AWARE			MILDLY AWARE			VERY AWARE
-3	-2	-1	0	+1	+2	+3

12. How compelling was your sense of objects moving through space?

NOT AT ALL			MODERATELY COMPELLING			VERY COMPELLING
-3	-2	-1	0	+1	+2	+3

13. How inconsistent or disconnected was the information coming from your various senses?

NOT AT ALL INCONSISTENT			SOMEWHAT INCONSISTENT			VERY INCONSISTENT
-3	-2	-1	0	+1	+2	+3

14. How much did your experience in the virtual environment seem consistent with real world experiences?

NOT CONSISTENT			MODERATELY CONSISTENT			VERY CONSISTENT
-3	-2	-1	0	+1	+2	+3

15. Were you able to anticipate what would happen next in response to the actions that you performed?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

16. How completely were you able to actively survey or search the environment using vision?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

17. How well could you identify sounds?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

18. How well could you localize sounds?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

19. How compelling was your sense of moving around inside the virtual environment?

NOT COMPELLING			MODERATELY COMPELLING			VERY COMPELLING
-3	-2	-1	0	+1	+2	+3

20. How closely were you able to examine objects?

NOT AT ALL			PRETTY CLOSELY			VERY CLOSELY
-3	-2	-1	0	+1	+2	+3

21. How well could you examine objects form multiple viewpoints?

NOT AT ALL			SOMEWHAT			EXTENSIVELY
-3	-2	-1	0	+1	+2	+3

22. How well could you move or manipulate objects in the virtual environment?

NOT AT ALL			SOMEWHAT			EXTENSIVELY
-3	-2	-1	0	+1	+2	+3

23. To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?

NOT AT ALL			MILDLY DISORIENTED			VERY DISORIENTED
-3	-2	-1	0	+1	+2	+3

24. How involved were you in the virtual environment experience?

NOT INVOLVED			MILDLY INVOLVED			COMPLETELY ENGROSSED
-3	-2	-1	0	+1	+2	+3

25. How distracting was the control mechanism?

NOT AT ALL			MILDLY DISTRACTING			VERY DISTRACTING
-3	-2	-1	0	+1	+2	+3

26. How much delay did you experience between your actions and expected outcomes?

NO DELAYS			MODERATE DELAYS			LONG DELAYS
-3	-2	-1	0	+1	+2	+3

27. How quickly did you adjust to the virtual environment experience?

NOT AT ALL			SLOWLY			LESS THAN ONE MINUTE
-3	-2	-1	0	+1	+2	+3

28. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

NOT PROFIECIENT			REASONABLY PROFICIENT			VERY PROFICIENT
-3	-2	-1	0	+1	+2	+3

29. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

NOT AT ALL			INTERFERED SOMEWHAT			PREVENTED PERFORMANCE
-3	-2	-1	0	+1	+2	+3

30. How much did the control devices interfere with the performance of assigned tasks or with other activities?

NOT PROFICIENT			REASONABLY PROFICIENT			VERY PROFICIENT
-3	-2	-1	0	+1	+2	+3

31. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

NOT AT ALL			SOMEWHAT			COMPLETELY
-3	-2	-1	0	+1	+2	+3

32.

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